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UNITED STATES POSTAL SERVICE
U.S.MAIL

Maintenance of Electrical Switchgear

Maintenance Series Handbook MS-28

P1.31/6:

U.S. Postal Service
Washington, DC 20260

Operation and Maintenance Handbook
Maintenance of Electrical Switchgear
HBK MS-28

Transmittal Letter 2

March 15, 1986

A. EXPLANATION

The attached handbook is a complete revision of HBK MS-28, and provides technical requirements for maintenance of electrical switchgear.

B. DISTRIBUTION

1. Initial. Copies of this complete issue are being distributed to all Maintenance Capable Offices, Management Sectional Centers, Division Offices, Bulk Mail Centers, Regional Offices, and Postal Employee Development Centers.

2. Additional Copies. Order additional copies directly from your supply center on Form 7380, Supply Center Requisition.

C. RECISIONS

All copies of the original issue of HBK MS-28, TL1, are rescinded and should be discarded.

D. COMMENTS AND QUESTIONS

Recommendations for improving the guidelines, information, and procedures contained in this handbook are solicited from all sources. Anyone wishing to make such recommendations should submit them to:

Field Director
Maintenance Technical Support Center
P.O. Box 1600
Norman, OK 73070-6708

E. EFFECTIVE DATE

These instructions are effective upon receipt.

Peter A. Jacobson
Acting Assistant Postmaster General
Engineering and Technical Support
Department

maintenance
handbook

Maintenance of Electrical Switchgear

Maintenance Series Handbook MS-28

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FOREWORD

This Handbook explains, in general, electrical switchgear maintenance for postal facilities. It is divided into chapters that pertain to specific aspects of electrical switchgear maintenance.

This Handbook may be used as a source for planning, equipment selection, training, and general electrical switchgear maintenance information. Numerous references to both postal and non-postal documents are contained in each chapter.

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CHAPTER 1

INTRODUCTION

110 PURPOSE

111 Scope

This Handbook contains information on safety practices when working on switchgear, descriptions of typical classes of switchgear, and preventive and corrective maintenance guidelines for switchgear. Also, information is presented to assist local Postal Service personnel in establishing an effective preventive maintenance program for their facility. Since many facilities are not able to perform all required maintenance with local personnel, information is given on what provisions should be considered in contracting for these services.

112 Types of Switchgear

This Handbook provides general guidelines for the proper maintenance of electrical switchgear used in postal facilities. Specific models of switchgear apparatus are not described in detail because of the large variety of models available. Rather, maintenance information is presented for five classes of switchgear equipment:

a. Transformers

b. Circuit Breakers

c. Relays

d. Connection Equipment

e. Motor Starters 200 H.P. and Above

113 Use

Postal Service installations range from the small facility with residential type single-phase power to the very large facility with incoming service voltages to 13.8 kV (kilovolts) and capabilities of over 1000 kVA (kilovolt Amps). In any installation the switchgear equipment is designed to trip or otherwise open the electrical circuits in the event of malfunction of connected equipment. This automatic disconnect function is required to protect the personnel, the postal facility, equipment, and the utility providing the electrical service. Naturally, larger facilities have the more elaborate and costly switchgear. However, to function properly when needed, all switchgear requires maintenance.

120 MAINTENANCE

121 Need For Maintenance

Unreliable or inoperable protective devices are not suitable for use, these devices may result in damage to other equipment, fire, or death, or injury to personnel. The increasing reliance of the Postal Service on automatic, electrically powered and controlled mail processing equipment in recent years means that any serious power failure in a Postal Service facility will significantly reduce the facility's ability to process mail. Therefore, to prevent damage or injury and to meet the requirements for mail processing, the Postal Service must ensure that electrical switchgear functions properly.

122 Benefits of Maintenance

Only a program of electrical apparatus testing under simulated or actual operating conditions combined with regularly scheduled preventive maintenance, will ensure the reliability of electrical switchgear. Conclusive electrical tests, properly applied, will determine if equipment is operating properly, if it needs repair, or if it should be replaced with newer, more modern apparatus.

Regularly scheduled maintenance has many benefits. It permits more than a routine inspection of equipment, and allows time for more thorough maintenance to be performed. Equipment can be cleaned, inspected, lubricated, mechanically checked, and operated. Thorough maintenance results in improved apparatus performance, higher reliability, and a reduction in the number of unexpected problems which can occur on poorly maintained equipment.

NOTE

Do not check the condition of inaccessible parts in an energized or operating state. Attempting to check such parts when energized or operating is an unsafe practice. See Chapter 2, Safety.

123 Elements of an Effective Maintenance Program

A number of elements are required to establish and operate an effective maintenance program for electrical switchgear. These elements are:

a. A thorough knowledge of the facility switchgear and distribution equipment and its characteristics, including one-line and control diagrams.

b. Adequate training for employees operating electrical switchgear.

c. Sufficient properly trained maintenance personnel to perform maintenance actions.

d. Coordination between Operations and Maintenance, particularly in regard to scheduling of equipment down time.

e. Proper tools and test equipment to perform all required tests, inspections, adjustments, cleaning, and repair.

f. Appropriate spare parts on site to accomplish needed repairs.

g. A record system to schedule, report on, and control all maintenance activities.

124 Contract Maintenance

124.1 Need for Contract Maintenance

Many postal facilities, because of a lack of capabilities in one or more of the elements listed above, must obtain maintenance service from outside contractors. If the facility cannot inspect, test, and maintain its vital electrical apparatus, it must, through its Procurement Services Officer, contract this service to someone who can.

124.2 Contract Maintenance Requirements

Contract maintenance must be tailored to a particular facility. Some facilities may need a presite contract.

The contractor or facility staff should be required to perform a preliminary survey of facility equipment to identify equipment inventory, interconnection wiring, and equipment needing maintenance or repair. The survey should list hazardous conditions, and recommend preventive maintenance schedules.

Local management must determine what preventive and corrective maintenance may be performed by the facility staff.

If needed, a maintenance contract must be drawn up for scheduled inspection, cleaning, and minor repair.

If needed, a contract must be drawn up for assistance in repairing major failures and any problems identified during the preliminary survey or scheduled maintenance.

124.3 Danger Area

If the majority of a facility's electrical equipment is 5 years or older and has never been completely overhauled, or if regular maintenance does not go further than superficial requirements, then the equipment is in the DANGER AREA, and may be permanently damaged.

If the facility cannot inspect and maintain its equipment, it must contract this service out. The facility management is responsible for proper maintenance.

NOTE

See Chapter 7 for a more extensive discussion of contract maintenance.

130 REFERENCE LIBRARY

The Manager, Plant and Equipment Engineering of each postal facility must maintain an up-to-date electrical maintenance library to include but not limited to the following:

a. The National Electrical Code Handbook

b. NFPA 70-B, Electrical Equipment Maintenance

c. The National Electrical Safety Code

d. Electrical Equipment Testing and Maintenance by A.S. Gill (Reston Publishing Company) Division of Prentice Hall Co., Reston, Virginia.

In addition, the Manager, Plant and Equipment Engineering, must provide each employee engaged in building electrical work access to a current copy of the National Electrical Code and the National Electrical Safety Code.

CHAPTER 2

SAFETY

210 GENERAL

Because of the extremely dangerous voltages and currents present in electrical switchgear, precise attention must be paid to safety rules and proper working conditions, to protect both personnel and equipment. Normally, all maintenance work is performed only on completely deenergized equipment. However, under very special conditions some work may be performed on energized equipment (see 232.1). In any case the safety rules outlined below must be followed.

220 QUALIFIED PERSONNEL

221 Maintenance

The Manager, Plant and Equipment Engineering or designee will ensure personnel are qualified by reviewing documented education, training and expertise, both postal and private. Only currently qualified personnel may perform preventive or corrective maintenance on electrical switchgear.

222 High Voltage Maintenance (600 Volts or Higher)

High voltage electrical maintenance is done by contract and not by USPS personnel unless an exception has been specifically approved by the Office of Maintenance Management (OMM). The requirements in HBK MS-1, Operation and Maintenance of Real Property, must be followed by USPS staff.

230 SAFETY RULES

231 Deenergized Equipment

231.1 Deenergized Procedures

Prior to commencing work on deenergized electrical switchgear, a qualified maintenance employee, other than the person who deenergized the equipment, must verify the equipment as deenergized. He must attach a Form 4811 Equipment Lockout Tag, or a Keep Out Tag Form 4812 High Voltage Equipment Lockout Tag, to the circuit disconnect switch. Whenever possible, the employee must place a lock on the switch to prevent accidental closing of the switch. The use of a lockout device, NSN 5975-00-000-4495, is recommended. This device will accomodate up to six padlocks, one for each person working on the circuit.

231.2 Reenergizing Procedures

All persons must be clear before circuit can be reenergized. The senior person must personally test the circuit at the point of work to positively determine

that the circuit is dead, and the downstream load is deenergized before energizing the main circuit breaker.

NOTE

Safeguards to protect other personnel; danger signs, roped-off space, barriers, etc., must be used if the nature or location of the work creates a hazard.

231.3 Work Procedures

The supervisor must ensure that each member of the work crew is familiar with the work to be done and that each person is aware of all specific safety procedures to be followed. Cleaning of switchgear equipment must be performed with insulated vacuum cleaning equipment or low pressure (less than 30 psi) pressurized air. High voltage power circuits must have conductors shorted to ground after deenergization by a hot-line grounded device approved for the purpose. Forms 4811 and 4812 and switch lock may be removed when the job is complete only by the person who "tagged" the equipment and has ensured that all persons are clear of the circuit.

NOTE

"Dead circuits" must always be treated the same as "live" circuits until they are proved to be dead. This practice develops a caution that may prevent an accident. A circuit may be energized through the error of some other person, back feed, or an automatic feed from another source.

232 Energized Equipment

232.1 Policy

When it is necessary to have work performed on energized equipment, and when the work practices stated below are in effect, USPS maintenance personnel are authorized to work on energized equipment.

232.2 Procedures

a. The Manager, Plant and Equipment Engineering for the facility must individually authorize each job.

b. All work must be performed by qualified personnel who are familiar with the National Electrical Code, National Electrical Safety Code-ANSI C2-1984, and other applicable codes.

c. When work is in progress, two or more people experienced in high voltage work must be present at all times, if the voltage of the systems or equipment being worked on exceeds 600 volts.

d. All energized parts and working personnel must be effectively guarded by the use of protective equipment, such as; rubber gloves, rubber blankets and floor mats, hot-line tools, switchsticks, and testing and grounding devices, to protect persons or objects from harmful contact.

e. All protective equipment used on energized lines or circuits must be approved, periodically examined, tested (by a certified test facility), and kept in a safe condition. Rubber gloves must be thoroughly examined and air tested prior to use each time they are used.

f. When working on energized equipment, approved safety glasses must be worn by all personnel at all times.

g. When cleaning energized equipment, care must be taken to prevent short circuits caused by blowing heavy accumulations of dirt onto exposed electrical contacts.

240 USE OF RUBBER GLOVES

241 Inspection of Rubber Gloves

241.1 Required Inspections

Before insulating rubber gloves are used, a visual inspection and air test must be done.

241.2 Visual Inspection

Stretch a small area of the glove and check for embedded metal or foreign material, deep cuts or scratches, pin holes or punctures, or any other sign of deterioration. Inspect the entire glove including the gauntlet. Any suspect or defective gloves must be destroyed and returned to the senior maintenance official.

241.3 Air Testing

After the visual inspection the rubber glove must be air tested. Inflate the glove by gripping the gauntlet and squeezing the palm, fingers, and thumb. Inspect the glove for defects. Then hold the glove near the face to detect air leakage.

Rubber gloves must be tested every six months by an independent testing contractor to assure that the gloves comply with ANSI/ASTM requirements.

NOTE

The shelf life of rubber gloves must be recorded and monitored. Sealed gloves in the original container do not require testing, provided they do not exceed their rated shelf life.

242 Leather Protector Gloves

Approved leather protector gloves must be worn over rubber gloves to protect the rubber glove from damage. The gloves must not be used as work gloves, and must be replaced if they become oil soaked, have faulty or torn stitching, holes, or cuts, or if for any other reason they cannot protect the rubber gloves.

250 USE OF INSULATING MATS

251 Inspection

Insulating mats required for high voltage switchgear maintenance must be visually inspected before use. Place the mat on a table and visually inspect each side for embedded metal or foreign material, cuts, cracks, abrasions, or any other abnormal condition. Defective mats must be tagged and returned to the senior maintenance official.

252 Protection

Insulating mats must be kept in a protective bag or other protective container to prevent damage or contamination. Under no circumstance may high voltage insulating mats be left on the floor or on equipment when maintenance is not being performed on the equipment.

253 Testing

Insulating mats must be tested every 12 months in accordance with ANSI/ASTM.

NOTE

The shelf life of mats must be recorded and monitored. Sealed mats in the original container do not require testing, provided they do not exceed their rated shelf life.

CHAPTER 3

EQUIPMENT DESCRIPTION

310 BACKGROUND

Because of the wide variety of different models and designs of electrical switchgear equipment in use today, this Handbook cannot present complete equipment descriptions. Detailed descriptions of switchgear equipment are available from a number of sources including manufacturer's catalogs and industrial electrical handbooks. Four useful industrial handbooks containing extensive equipment descriptions and application information are:

Switchgear and Control Handbook, Editor, Robert W. Smeaton.

Electrical Equipment Maintenance NFPA 70-B
National Fire Protection Association
Battery March Park
Quincy, MA. 02269-9101

Westinghouse Electrical Maintenance Hints, Westinghouse Electrical Corporation.

National Electrical Safety Code, IEEE.
Institute of Electrical and Electronics Engineers Inc.
345 East 47th St.
New York, NY 10017-2394

320 SWITCHGEAR EQUIPMENT CLASSES

This Handbook covers electrical equipment grouped into the following five classes.

a. Transformers

This equipment class includes both power and distribution type transformers whether dry or liquid (oil) filled. Generally these devices transform the high voltage of the utilities power input down to the appropriate voltages needed to operate building equipment. This class also includes current and potential transformers used to provide metering signals for the power circuits and voltages for the control circuitry.

b. Circuit Breakers

This class includes a wide variety of devices designed to break a circuit under certain conditions. The devices use thermal or magnetic elements, including relays, to respond to over- or under-current, or voltage conditions and mechanically interrupt the circuit path. Since these devices are designed to interrupt current-carrying circuits, an arc is formed when the circuit is broken. Several different methods are

used, including the use of insulating oil, to quench the arc rapidly. Many circuit breakers have both an instantaneous trip rating and an adjustable time delay rating.

c. Relays

This class also includes a wide variety of designs used in power circuits in many ways. Some relays operate when an abnormal circuit condition causes the relay, to open or close an auxiliary electric circuit, in turn tripping the switch or circuit breaker mechanism. Relays operate on thermal, magnetic, or induction principles and may be instantaneous or time delayed. Switchgear relays are normally used to sense under- or over-voltage or current, power factor, reverse current, phase unbalance, or other important circuit conditions.

d. Connection Equipment

This class of switchgear includes the apparatus used to interconnect utility power lines, transformers, power wiring, and protective devices. Connection equipment includes switchboards, disconnect switches, lightning protectors, power cables and insulation, and switchgear equipment vaults.

e. Motor Starters (200 H.P. and above)

330 SWITCHGEAR APPARATUS

The switchgear apparatus covered by this Handbook is differentiated and organized in the following sequence.

NOTE

When used in this Handbook, the designation high voltage refers to voltages in excess of 600 volts and low voltage refers to voltage below 600 volts.

331 Transformers

a. High voltage, liquid-filled, substation type, 500 kVA and up

b. High voltage, dry, 500 kVA and up

c. Distribution type, liquid filled, 500 kVA and below

d. Distribution type, dry, 500 kVA below

e. Current and potential types, dry

f. Transformer oil or air cooling equipment

332 Circuit Breakers

a. High voltage, oil filled

b. High voltage, air

c. Low voltage, 3-phase power

d. Low voltage, molded-case

333 Relays

a. Induction disc overcurrent

b. Induction disc directional overcurrent

c. Thermal overcurrent

d. Over- and under-voltage

e. Power factor, reverse current, or watt type

f. Transformer and bus differential; current balance

334 Connection Equipment

a. Switchboards

b. Disconnect switches

c. Lightning and network protectors

d. Power cables

e. Insulators

f. Power vaults

g. Bus Ducts

335 Motor Starters, 200 H.P. and above

CHAPTER 4

PREVENTIVE MAINTENANCE

410 PREVENTIVE MAINTENANCE PROGRAM

411 Responsibility

It is the responsibility of the Manager, Plant and Equipment Engineering to initiate and continue a preventive maintenance (PM) program. Initial set-up may require contracted services in the form of an electrical equipment survey (see Chapter 7). PM actions depend on the equipment installed and are listed in the PM guides (see 432).

NOTE

Any preventive maintenance performed by USPS employees must meet the requirements in Chapter 7.

412 Required Records

412.1 General

A record of the equipment installed in the facility must include: the name of the equipment, manufacturer, part number and series if applicable, and rating or descriptive performance characteristics. The inventory must be updated as required (see Chapter 7).

412.2 Diagrams and Schematics

The building records should contain as-built diagrams and schematics. The accuracy of the drawings must be checked by personnel having knowledge of electrical equipment. If drawings are not on file, and copies cannot be obtained, new drawings must be made. The drawings must have sufficient identification of parts and control relationships to allow troubleshooting in case of breakdown as well as planning preventive maintenance procedures and sequences. Any subsequent modifications to the equipment must be accompanied by suitable drawing revisions.

NOTE

If an electrical equipment survey is made by service contract, provisions must be made in the contract for drafting new or revised drawings.

412.3 Schedules and Plans

The inventory, drawings, and schematics, as well as records of maintenance schedules, actions, and modifications must be kept on file in a safe area as determined by the director of plant maintenance. The records of maintenance actions must include test results. A file of equipment history record cards can

be maintained for quick reference to specific equipment. A set of plans for shut down, power transfer, and start up procedures must be accessible to those responsible for dealing with emergencies. Such plans can be obtained from building operating instructions, developed in-house, or included in the requirements of a contractor's electrical equipment survey. The Manager, Plant and Equipment Engineering is responsible for keeping the plans and records current. Coordination settings must be on file for all protective relays, circuit breakers, and ground fault protection.

413 Required Tools and Equipment

The tools and test equipment required to perform preventive maintenance depends on the level of maintenance the office is qualified to perform. The cleaning of equipment requires ordinary cleaning materials and tools. Low voltage equipment can be maintained with typical electrician's tools. Tools and test equipment for performing the preventive maintenance specified in the guides are available from manufacturers of switchgear equipment and are described in their catalogs. Some test equipment must be calibrated.

414 Required Lead Time

All work must be scheduled at least four weeks in advance and coordinated with operation personnel so that the deenergized circuits have the least effect on mail processing operations. When possible, additional lead time (up to two months) should be allowed for planning. Work must be scheduled on evenings and weekends when necessary. Since the reliability of the building electrical power equipment is vital to mail processing operations, it is the responsibility of the Manager, Plant and Equipment Engineering to see that the preventive maintenance program is not ignored or postponed without serious cause.

420 MAINTENANCE GUIDELINES

Normally work must not done by USPS personnel on circuits or equipment unless they have first been deenergized. Conditions which may allow work on energized circuits include:

a. Line voltage, current, and similar tests made by electricians with proper instruments.

b. In an emergency cutting lines if there is no other way to interrupt a circuit and proper emergency equipment is used. This may only be necessary on tap conductors.

c. Replacement of fuses, by means of proper fuse pullers, in circuits of 480 volts or less. Load must be removed before fuses are replaced.

d. Low (under 600 volts), or high (over 600 volts) voltage switching and disconnecting, for the purpose of deenergizing circuits for maintenance, using the switching equipment designed for the purpose and following the recommended procedure and sequence developed for the system.

e. If contract personnel are not available, and it is necessary to maintain power on the system. In such situations, each job must be individually authorized by the Manager, Plant and Equipment Engineering or his designee and the guidelines in Chapter 2 must be followed.

430 ANNUAL PM PROCEDURES

431 Schedule

Preventive maintenance contract must be done on a yearly basis.

432 Action

432.1 High Voltage Liquid-Filled Transformers

Perform the following:

Special Instructions

a. Schedule and coordinate work with operating personnel.

b. Obtain and review manufacturers instructions.

c. Deenergize; tag and lock circuit; test circuit before beginning work.

d. Do not mix mineral oil with synthetic oil and use only clean containers to hold fluids. All tests must conform to the appropriate American Society for Testing Materials (ASTM) test procedure, and all values used as standards must conform to the manufacturers' recommendations and those of the American National Standard Institute (ANSI).

Checkpoints

a. Inspect for physical damage. Closely examine for all damage that may have occurred as the result of rodents, birds, environmental, or any other causes.

b. Verify proper auxiliary device operations such as fans, pumps, sudden pressure device indicators, tap changers, and gas pressurization systems.

c. Check tightness of external bolted electrical points.

d. Check all liquid in tanks and bushings for proper level and inspect for oil leaks.

e. Perform the specific inspection and mechanical tests as recommended by manufacturer.

f. Closely examine for dirt or other material that may have collected in the windings during normal operation. Examine for foreign material that may interfere with cooling or reduce efficiency.

g. Examine grounding wire for proper size and connection to electrode.

h. Clean and inspect accessible insulators for chips, cracks, or fractures.

i. Take an oil sample. Remove mineral or transformer oil samples from the bottom; Askarel and Pyronal samples should be removed from the top, and tested for:

Dielectric Strength

Neutralization Number

Color Number

Interfacial Tension

Minimum Acceptable Test Specification:

	Color #	Acidity.
Mineral Type	3.5 or Less	0.4 or Less (discard greater than 1.0)
Askarel Type	2.0 or Less	0.05 or Less

	Dielectric Strength	Interfacial Tension
Mineral Type	23 kV or more	22 Dynes or more
Askarel Type	26 kV or more	Not Applicable

NOTE

Oil samples may be sent to the following testing laboratories.

Southwest Power Equip. Co.
7501 Schneider St. (PH. # (713)-695-0666)
Houston, Texas 77093-8527

Technion
681 Main St. (PH. # (201)-759-0228)
Bellville, N.J. 07109-3404

j. Inspect for leaks and check oil level and reservior.

k. Tighten all connections.

l. Remove rust spots from body, caps, and flanges by sanding. Cover bare metal with rust inhibitor primer and paint.

432.2 Dry-Type Power Transformers

Perform the following:

Special Instructions

a. Schedule and coordinate all work with operating personnel.

b. Obtain and review the manufacturer's instructions.

c. Deenergize and tag circuit. The circuit usually must be cleared on primary beyond any primary disconnect switch.

Checkpoints

a. Throughly clean unit inside and out with a vacuum cleaner. Use low pressure air to blow dust from hard to reach areas.

b. Tighten all connections including tap connections with a torque wrench.

c. Inspect for signs of overheating or other defects, such as tracking.

d. Inspect spacing and rigidity of all conductors and support insulators.

e. Inspect operation of any fans or cooling apparatus.

f. Test operation of any temperature alarms or trips.

g. Clean all insulators with a soft cloth, and check for chips, cracks, or fractures.

432.3 Lightning Protection

Perform the following:

Special Instructions

a. Check to see that all air terminals (lightning rods) are interconnected.

Checkpoints

a. Inspect air terminals for corrosion and rigid attachment to structure.

b. Examine conductors for corrosion, strong mechanical joints providing good electrical conductivity, and loose or broken fasteners.

c. Check for damaged guards and down conductors.

432.4 Power Vaults

Perform the following:

Special Instructions

a. Equipment vaults must be maintained in a clean, dry, and ventilated condition at all times.

b. Doors on enclosures must be kept locked to prevent unauthorized access.

Checkpoints

a. Check insulators or insulating supports and bus runs after cleaning them.

b. Seals on conduit runs entering or leaving the vault must be checked to prevent entry of rodents and insects.

c. All switchgear containing transformer sections must be thoroughly cleaned inside as well as out.

432.5 Motor Starters, 200 Horsepower and Up

Perform the following:

Special Instructions

a. Deenergize and tag the circuit.

b. Obtain and review manufacturer's instructions for testing the starter (including the time current characteristic curve).

c. All tests must conform to the appropriate ASTM test procedure and the values used as standards must conform to the manufacturer's and ANSI Standards specifications.

Checkpoints

a. Visually inspect for any broken parts, contact arcing, or any evidence of overheating.

b. Check motor name plate for current rating and controller manufacturer's recommended heater size. (Heater size must not be changed without OMM's approval.)

c. Check line and load connections and heater mounting screws for tightness.

d. Clean all areas of equipment as needed.

432.6 Infrared Scanning of Electrical Equipment

Infrared scanning of all electrical equipment will be on an annual frequency (see 639.4).

CHAPTER 5

CORRECTIVE MAINTENANCE

510 GENERAL

Although a well planned and thorough preventive maintenance program reduces the chance of a power outage or switchgear failure there are times when equipment does fail. Such failures can seriously damage mail processing operations, and therefore must be corrected. The capabilities of the facility's maintenance department determine if the services of outside experts are needed. However, some troubleshooting and repair work is generally within the capabilities of the facility maintenance staff. Procedures and requirements for performing corrective maintenance are presented below.

520 REQUIRED PERSONNEL

Modern electrical maintenance requires much more than mechanical dexterity from the maintenance personnel. A good electrician or maintenance worker must be thoroughly familiar with the device or equipment worked on. Electrical workers must have sufficient electrical background, either from formal study or practical training, to evaluate electrical operating problems and to troubleshoot efficiently. A considerable knowledge of electrical theory is necessary, and the ability to read and interpret electrical drawings is mandatory. Local maintenance personnel can gain valuable training and experience by working with contractor personnel while the contractor personnel are performing test, evaluation, preventive, and corrective maintenance on the facility switchgear.

530 REQUIRED DOCUMENTS

Effective troubleshooting is extremely difficult without access to a well prepared documentation file that describes the equipment in use and contains complete and up to date wiring and schematic diagrams of the switchgear and distribution installation. Records of previous failures and repairs along with preventive maintenance records are of great benefit in analyzing troubles. Therefore, a paramount requirement for a facility maintenance operation is ensuring that a documentation file is established and kept up to date. The file should contain, as a minimum, the following:

a. Building plans showing switchgear installation and data.

b. An accurate one-line diagram of the electrical distribution system for the facility and coordination study, if required (see Chapter 7).

c. Manufacturer's data on all switchgear equipment.

d. Preventive maintenance records (see Chapter 4 for suggested types).

e. Records of repairs and modifications.

f. The facility's maintenance policies and procedures.

g. A switchgear maintenance logbook for batteries (if applicable).

h. Adequate documented safety procedures.

540 REQUIRED SPARE PARTS

An analysis of the equipment inventory and personnel capabilities must be performed to determine what equipment spare parts are needed in order to effect repairs with a minimum of downtime. One source for a recommended list of spare parts might be the outside contractor who performed an installation survey. Also, manufacturer's data should give some indication as to what spares must be stocked for repairs. These spares must be procured and placed under the spare parts inventory control system used for mail processing equipment spares. Records of spare parts usage must be kept.

550 REQUIRED TOOLS AND EQUIPMENT

Troubleshooting and repair of low voltage switchgear apparatus requires the use of common electricians' hand tools and test equipment. However, work on high voltage equipment requires specialized safety equipment and specialized test equipment. Generally, test equipment required for such actions as circuit breaker trip current tests, cables and insulation breakdown strength tests, and similar tests is too expensive and complex to justify its procurement by a facility.

The lockout device recommended for coordinating the work of mechanics and electricians on electrical equipment is NSN 5975-00-000-4495. One device should be provided to each mechanic and electrician who will have responsiblity for disconnecting power on equipment during maintenance.

CHAPTER 6

STATEMENT OF WORK FOR ELECTRICAL SWITCHGEAR TESTING AND PM CONTRACT

610 GENERAL

611 Scope

Tests ensure that all electrical equipment is operational within industry and manufacturer's tolerances and is installed in accordance with design specifications. The tests and inspections determine the suitability of continued use. These tests must be conducted every three years.

612 Applicable Codes, Standards and References

612.1 Codes and Standards

All inspections and tests must be in accordance with the following applicable codes and standards except as provided otherwise herein.

a. National Electrical Code (NEC).

b. National Electrical Manufacturer's Association (NEMA).

c. American Society for Testing and Materials (ASTM).

d. Institute of Electrical and Electronic Engineers (IEEE).

e. American National Standards Institute (ANSI).

f. State and Local Codes and Ordinances.

g. Insulated Power Cable Engineers Association (IPCEA)

h. Association of Edison Illuminating Companies (AEIC).

i. OSHA Part 1910; Subpart S, 1910.308

612.2 References

All inspections and tests must use the following reference materials:

a. Existing Coordination Study - Set Points.

b. One-Line Drawings and Switchgear Control Drawing.

c. Manufacturer's instruction manuals applicable to each particular apparatus.

620 CONTRACTOR TESTING

621 Qualifications

621.1 Testing Contractor

The testing contractor must meet federal OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907, and must submit proof of the above qualifications to the contracting officer.

621.2 Appraisers and Testers

The engineering appraisal and testing organization must have three or more years experience related to the appraisal and testing of apparatus designated herein. The organization must be able to identify suitable engineering and technical resources to complete work under approved schedules. A list of prior jobs that have been completed must be available.

622 Responsibilities

622.1 USPS Responsibilities

When a contractor performs a facility's testing, the USPS is responsible for:

a. Supplying a suitable and stable source of test power consisting of existing in-house power, to the test at each test site.

b. Notifying the testing contractor when equipment is available for tests.

c. Coordinating work to expedite project scheduling.

d. Supplying a complete set of electrical plans, specifications, and any pertinent change orders to the contractor before testing.

622.2 Contractor Responsibilities

When testing, a contractor is responsible for:

a. Notifying the USPS prior to any testing.

b. Implementing all final settings and adjustments on protective devices and tap changes. Any deviation from found settings must be reported to the senior maintenance official.

c. Reporting directly to the USPS of any system material or workmanship which is found defective on the basis of test.

d. Maintaining a written record of all tests, and upon completion of project, assembling and certifying a final test report.

e. Providing copies of the report to the USPS along with original thermograph pictures.

f. Providing all labor, equipment, and personnel to perform tests and inspections on all electrical equipment listed in Chapter 3.

623 Testing Guidelines

623.1 General

The following list provides guidelines for tests. The list is quite extensive to cover all sites and situations. Use only those portions that apply to your installation.

623.2 Test Instruments

The testing contractor must use a calibration program that maintains all applicable test instrumentation within rated accuracy that can be traced to the National Bureau of Standards in an unbroken chain. Instruments must be calibrated in accordance with the following frequency schedule:

a. Field instruments - 6 months maximum.

b. Laboratory instruments - 12 months maximum.

c. Leased speciality equipment - 12 months (where accuracy is guaranteed by lessor, e.g. Doble).

NOTE

Dated calibration labels must be visible on all test equipment.

623.3 Test Report

The test report must include the following:

a. Summary of project.

b. Description of equipment tested.

c. Description of test.

d. List of test equipment used in calibration and calibration date.

e. Test results.

f. Conclusions and recommendations.

g. An appendix, including appropriate test forms.

NOTE

The test report must be bound and its contents certified.

Three copies of the completed report must be furnished to the USPS no later than thirty (30) days after completion of project unless directed otherwise. A more extensive discussion of contractor work is found in Chapter 7.

624 Safety and Precautions

624.1 Applicable References

Safety practices must include, but are not limited to, the following requirements:

a. Occupational Safety and Health Act of 1970 - OSHA and current revisions.

b. Accident Prevention Manual for Industrial Operations, Seventh Edition, National Safety Council, Chapter 4.

c. Applicable State and Local safety operating procedures.

All tests must be performed with apparatus deenergized unless specifically required in Chapters 7 and 8.

Circuits operating in excess of 600 volts between conductors must have conductors shorted to ground by a hot-line grounded device approved for the purpose.

The testing contractor must provide a designated safety representative for the project to determine when it is safe to proceed with work, and to supervise all the safety aspects.

The testing contractor must provide sufficient protective barriers and warning signs to conduct specified tests safely.

630 INSPECTION AND TEST PROCEDURES

631 Metal Clad Enclosures Switchboard Assemblies - General

Visual and Mechanical Inspections.

Perform the following inspections and tests:

a. Inspect for physical, electrical, and mechanical condition.

b. Compare equipment nameplate information with the latest one-line diagram and report all discrepancies.

c. Inspect for proper alignment, anchorage, and grounding.

d. Inspect all bus connections for high resistance, using a resistance ohmmeter, and check tightness of bolted bus joints by using a calibrated torque wrench.

NOTE

Refer to manufacturer's instruction for proper foot pound levels. If connections are not accessible, an infrared survey should be made with system in operation to identify high resistance connections.

e. Key interlock systems must be physically tested to ensure proper function. Closure attempt must be made on locked open devices. Opening attempt must be made on locked closed devices.

NOTE

When working on key interlock systems, key exchange procedures must be observed at both the beginning and end of the job, which will ensure that the system cannot be energized without the knowledge of all individuals involved.

f. All doors, panels and sections must be inspected for paint, dents, scratches and fit.

g. Inspect for cleanliness and need of lubrication.

h. Exercise all active components.

i. Inspect all indicating devices for proper operation.

Electrical Tests

a. Measure insulation resistance of each bus section phase to phase and phase to ground for one (1) minute. Test voltage and minimum acceptable resistance values must be in accordance with Table 6-1.

b. Perform overpotential test on each bus section phase ground. Potential application must be for one (1) minute. Test voltage must be in accordance with Table 6-1 and/or manufacturer's recommendations.

c. Measure insulation of control wiring to ground.

d. Use the elementary diagrams of the metal clad switchgear to identify each remote control and protective device. Conduct tests as required to verify satisfactory performance of each of the control features.

e. Determine available fault current from utility or primary source and compare with main circuit breaker interrupting capability.

f. Bolt torque levels must be in accordance with Table 6-2 unless otherwise specified by manufacturer.

TABLE 6-1

INSULATION RESISTANCE TEST VOLTAGE

Voltage Rating	Test Voltage
150-600V	1000V
601-5000V	2500V
5001-	5000V

Values of insulation resistance less than manufacturer's minimum or kV + 1 in megohms should be investigated. Overpotential tests must not proceed until insulation resistance levels are raised to said minimum.

TABLE 6-2

U.S. Standard

BOLT TORQUES FOR BUS CONNECTIONS

Heat Treated Steel

GRADE	SAE 1 & 2	SAE 5	SAE 6	SAE 8
MINIMUM TENSILE (PSI)	64K	105K	133K	150K
BOLT DIAMETER	TORQUE (FOOT POUNDS)			
1/4	5	7	10	10.5
5/16	9	14	19	22
3/8	15	25	34	37
7/16	24	40	55	60
1/2	37	60	85	92
9/16	53	88	120	132
5/8	74	120	167	180
3/4	120	200	280	296
7/8	190	302	440	473
1.	282	466	660	714

NOTE

Reduce torque by 20% when Cadmium plated bolts are used.

TABLE 6-3

INSULATION RESISTANCE
CONVERSION FACTORS

FOR CONVERSION OF TEST
TEMPERATURE TO 20°C

TEMPERATURE		TRANSFORMER	
°C.	°F.	OIL	DRY
0	32	.25	.40
5	41	.36	.45
10	50	.50	.50
15	59	.75	.75
20	68	1.00	1.00
25	77	1.40	1.30
30	86	1.98	1.60
35	95	2.80	2.05
40	104	3.95	2.50
45	113	5.60	3.25
50	122	7.85	4.00
55	131	11.20	5.20
60	140	15.85	6.40
65	149	22.40	8.70
70	158	31.75	10.00
75	167	44.70	13.00
80	176	63.50	16.00

632 Transformers

632.1 Liquid-Filled Transformers

Visual and Mechanical Inspections.

Perform the following inspections and tests:

a. Inspect for physical damage. Closely examine for all damage that may have occurred as the result of rodents, birds, environmental, or any other causes.

b. Compare equipment nameplate information with latest one-line diagram and report all discrepancies.

c. Verify proper auxiliary device operation by examining fans, pumps, sudden pressure devices, indicators, tap changers, and gas pressurization systems.

d. Check tightness of all external bolted electrical joints.

e. Check liquid in tanks and bushings for proper level and inspect for oil leaks.

f. Perform all specific inspections and mechanical tests as recommended by manufacturer.

Electrical Tests

a. Insulation resistance tests must be performed winding to winding and winding to ground. Appropriate guard circuits must be used over all bushings.

b. A turns ratio test must be performed between windings for all tap positions. The equipment owner determines the final tap setting, which is set by the testing contractor.

c. Measure secondary voltage phase to phase and phase to ground after final energizing and prior to loading.

d. Insulating oil must be sampled in accordance with ASTM D-923. Sample must be laboratory tested for:

(a) Dielectric strength

(b) Acid neutralization number

(c) Interfacial tension

(d) Color

(e) Power factor

(f) Parts Per Million (PPM) water (only required on units above 69 kV)

e. Measure dew point and/or oxygen content of top gas when applicable.

f. A complete dissolved combustible gas analysis on all transformers over 50 kVA must be conducted annually. Analysis must include interpretation by Roger's Ratio and Dorenberg Method. See Appendix "A".

g. Perform special tests and adjustments as suggested by manufacturer on tap changer, fan, and pump control and alarm functions.

h. (Optional) A dielectric absorption test can be made winding to winding and winding to ground for ten (10) minutes. The polarization index is computed as the ratio of the ten (10) minute to the one (1) minute reading.

i. (Optional) Insulation power factor tests can be made on all high and low voltage winding and bushings. Overall dielectric loss and power factor (C_H, C_L, C_{HL} must be determined). Underground specimen tests (UST) shall be made on any bushings equipped with power factor or capacitance taps.

j. (Optional) Individual exciting current tests must be performed on each phase in accordance with established procedures.

k. (Optional) Winding resistance tests must be made for each winding at nominal tap position.

Test Values

a. Insulation resistance and absorption test. Test voltages to be in accordance with Table 6-1. Resistance values to be temperature corrected in accordance with Table 6-3.

b. The absorption test polarization index should be above 2.0 unless an extremely high value is obtained at the end of one (1) minute that when doubled will not yield a meaningful value with the available test equipment.

632.2 Transformers - Dry Type

Visual and Mechanical Inspections.

Perform the following inspections and tests:

a. Inspect for physical damage, and mechanical and electrical conditions.

b. Compare equipment nameplate information with latest one-line diagram and report all discrepancies.

c. Verify that proper auxiliary device operation such as fans and indicators are in accordance with manufacturer's recommendations.

d. Check tightness of accessible bolted electrical joints in accordance with Table 6-2.

e. Perform specific inspections and mechanical tests recommended by manufacturer.

f. Closely examine for shipping brackets or fixtures that may not have been removed during original installation. Ensure that resilient mounts are free.

g. Closely examine for the collection of dirt or other forms of material that may have collected in the windings during normal operation. Any foreign material which may interfere with cooling, or reduce clearances to ground, must be removed using accepted methods.

Electrical Tests

a. Insulation resistance tests must be performed winding to winding and winding to ground.

b. A dielectric absorption test must be made winding to winding and winding to ground for ten (10) minutes. The polarization index must be computed.

c. Insulation power factor tests must be made from winding to winding and from each winding to ground.

d. A turns ratio test must be performed between windings.

e. Overpotential test must be made on all high and low voltage winding to ground.

f. Winding resistance tests must be made for each winding at nominal tap position.

g. Perform special tests and adjustments as suggested by manufacturer for fans, controls, and alarm functions.

h. Measure secondary voltage phase to phase and phase to ground after final energizing and prior to loading.

i. (Optional) Individual exciting current tests must be performed on each phase in accordance with established procedure.

Test Values

a. Insulation resistance and absorption test voltage must be in accordance with Table 6-1. All results are temperature corrected in accordance with Table 6-3.

b. The absorption test polarization index must be above 2.0 unless an extremely high value is obtained at the end of one (1) minute that when doubled must not yield a meaningful value with the available test equipment.

c. Power factor test values in excess of three percent (3%) must be investigated.

d. Winding resistance test results must compare within one percent (1%) of adjacent windings.

e. Turns ratio test results must not deviate more than one half of one percent (0.5%) from calculated ratio.

633 Conductors

633.1 High Voltage Cables

Visual and Mechanical Inspections.

Perform the following inspections and tests:

a. Inspect any exposed section for physical damage.

b. Verify cable is supplied and connected in accordance with one-line diagram.

c. Inspect for shield grounding, cable support, and termination.

d. Check visible cable bends against IPCEA or the manufacturer's minimum allowable bending radius.

e. Inspect for proper fireproofing in common cable areas.

f. If cables are terminated through window-type Current Transformers (C.T.), examine to verify that neutrals and grounds are properly terminated for normal operation of protective devices.

g. Visually inspect jacket and insulation condition.

Electrical Tests

Perform DC High Potential Proof Test:

a. Each conductor must be individually tested with all other conductors grounded. All shields must be grounded.

b. Terminations must be properly corona suppressed.

c. A DC high potential must be applied in equal increments until maximum test voltage is reached. DC leakage current must be recorded at each step after a constant stabilization time consistent with system charging current decay.

d. A graphic plot must be made of leakage current versus voltage.

e. The test conductor must be raised to a maximum test voltage and held for a total of ten (10) minutes. Reading of leakage current versus time must be recorded and plotted.

f. The applied conductor test potential must be reduced to zero (0) and grounds must be applied for a period adequate to drain all insulation stored potential.

g. Maximum test voltages must be in accordance with applicable IPCEA, AEIC and manufacturer's recommended 60% levels.

h. Check shield continuity with an ohmmeter. Ohmic value must be recorded.

Test Values.

DC High Potential test results should mirror the following:

a. Step voltage slope must be reasonably linear.

b. Absorption slope must be flat or negative. In no case must slope exhibit positive characteristic.

c. Current delay rate must be uniform.

633.2 Low Voltage (600 Volts and Less) Cables

Visual and Mechanical Inspections.

Perform the following inspections and tests:

a. Inspect for physical damage and proper connection in accordance with one-line diagrams.

b. Torque test cable connections to manufacturer's recommended values.

Test Values

a. Insulation resistance tests must be performed at 1000 Volts DC for 1/2 minute.

633.3 Metal Enclosed Bus Duct

Visual and Mechanical Inspections.

Perform the following inspections and tests:

a. Inspect the bus for physical damage, cleanliness, and proper connection in accordance with one-line diagram.

b. Inspect for proper bracing, suspension alignment, and enclosure ground.

c. Check tightness of all bolted joints with a calibrated torque wrench.

d. In some cases a thermographic survey can be made to evaluate the connections of the bus duct. This must be made with the unit operating under maximum loaded conditions.

e. Closely inspect the bus enclosure for any indication of environmental influence or any foreign material that might affect insulation resistance by reducing clearance phase to phase or phase to ground.

Electrical Tests

a. Measure insulation resistance of each bus run phase to phase and phase to ground for one (1) minute.

b. Perform overpotential tests on each bus run phase to phase and phase to ground as necessary.

Test Values

a. Bus bolt torque values must be in accordance with manufacturer's recommendations.

b. Insulation resistance test voltage must be in accordance with Table 6-1. Resistance values must be in accordance with manufacturer's values.

633.4 Outdoor Bus Structures

Visual and Mechanical Inspections.

Perform the following inspections and tests:

a. Examine bus and supports for defects, such as cracked welds, chipped porcelain, etc.

b. Check tightness of accessible bolted bus joints with a calibrated torque wrench. Refer to manufacturer's instructions for proper foot pound levels. In the absence of specific instructions use Table 6-2.

c. Inspect for evidence of foreign material such as bird nests, dust, and missing or damaged rain guards.

d. Inspect for cleanliness.

Electrical Tests

a. Measure insulation resistance of each bus section phase to phase and phase to ground for one (1) minute.

b. Perform overpotential test on each bus section phase to phase and phase to ground. Potential application must be for one (1) minute.

c. Measure resistance of bus section joints with microohmmeter or "ductor", preferably at a high current.

Test Values

a. Bolt torque levels must be in accordance with Table 6-2 unless otherwise specified by manufacturer.

b. Insulation resistance test values must be in accordance with Table 6-1.

c. Measured bus joint resistance must be compared to calculated resistance of bus. Investigate resistances above one hundred fifteen percent (115%) of calculated value.

634 Switches

634.1 High Voltage Air Switches

Visual and Mechanical Inspections.

Perform the following inspections and tests:

a. Inspect for physical damage.

b. Perform mechanical operator tests in accordance with manufacturer's instructions.

c. Check blade alignment and arc interrupter operation.

d. Check fuse linkage and element for proper holder and current rating.

e. Check each fuse holder for adequate mechanical support of each fuse.

f. Check key interlocks for safe operation and proper key distribution.

Electrical Tests

a. Perform insulation resistance test on each phase to ground and from phase to phase.

b. Perform overpotential test on each pole to ground and pole to pole.

c. Perform contact resistance test across each switch blade and fuse holder.

Test Values

Contact resistance must be determined in microohms. Any value exceeding 50 microohms or any value which deviates from adjacent poles or similar switches by more than fifty percent (50%) must be investigated.

634.2 Automatic Transfer Switches

Visual and Mechanical Inspections.

Perform the following inspections and tests:

a. Inspect for physical damage.

b. Check switch to ensure positive interlock between normal and alternate sources (mechanical and electrical).

c. Check tightness of all control and power connections.

d. Perform a manual transfer operation.

e. Ensure mechanical breaker reset function.

Electrical Tests

Perform insulation resistance tests phase to phase, and phase to ground with switch in both source positions.

Check calibration of following:

a. Voltage sensing relays.

b. Transfer time delay relay.

c. Engine shutdown relay.

Perform an automatic transfer by:

a. Simulating loss of normal power.

b. Transferring time delay relay.

c. Engine shutdown relay.

Perform automatic transfer by:

a. Simulating loss of normal power.

b. Returning to normal power.

Monitor and verify correct operating and timing by:

a. Normal voltage sensing relays.

b. Engine start sequence.

c. Time delay upon transfer.

d. Alternate voltage sensing relays.

e. Automatic transfer operation.

f. Interlocks and limit switch function.

g. Timing delay and retransfer upon normal power restoration.

h. Engine shutdown feature.

Test Values

Insulation resistance test voltages and minimum values to be in accordance with Table. 6-1.

635 Circuit Breakers

635.1 High Voltage (Air) Circuit Breakers

Visual and Mechanical Inspections.

Perform the following inspections and tests:

a. Inspect for physical damage, cleanliness, and adequate lubrication.

b. Inspect anchorage, alignment, and grounding.

c. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism in accordance with manufacturer's instruction.

d. Check tightness of bolted bus joints with a calibrated torque wrench. Refer to manufacturer's instruction for proper foot pound levels.

e. Check the cell fit and element alignment.

f. Using the manufacturer's instruction book, verify the primary and secondary contact wipe and other dimensions vital to satisfactory operation of the circuit breaker.

g. Ensure that all maintenance devices are available for servicing and operating equipment.

Electrical Tests

a. Measure contact resistance.

b. Perform minimum pickup voltage tests on trip and close coils.

c. Perform insulation resistance tests, pole to ground, pole to pole, and across open pole.

d. Perform insulation resistance test at 1000 volts DC on all control wiring (do not perform the test on wiring connected to solid state relays).

e. If charging motors are used, check condition of brushes and limit switches.

f. Perform overpotential tests, or power factor tests with breaker in both the open and closed positions. All arc chutes must be tested for watts loss.

Test Values

a. Contact resistance must be determined in microohms. Resistance values must not exceed 500 microohms. Consult the manufacturer for acceptable range.

b. Power factor and arc chute watts loss must be no greater than the manufacturer's allowable value.

635.2 Circuit Breakers - (Oil)

Visual and Mechanical Inspection.

Perform the following inspections and tests:

a. Inspect for physical damage, cleanliness, and compare nameplate data with plans and specifications. Check all gasketed covers and seals for weather tightness.

b. Inspect anchorage, alignment, and grounding.

c. Perform all mechanical operation and contact alignment tests on both the circuit breaker and its operating mechanism in accordance with manufacturer's instruction.

d. Check tightness of bolted bus joints with a calibrated torque wrench. Refer to manufacturer's instructions for proper foot pound levels.

e. Using the manufacturer's instruction book, verify the primary and secondary contact wipe and other dimensions vital to satisfactory operation of the circuit breaker.

Electrical Tests

a. Measure contact resistance.

b. Perform breaker travel time test if unit is properly equipped for it.

c. Sample insulating liquid. Sample must be laboratory tested for:

(a) Dielectric Strength

(b) Acid Neutralization Number

(c) Interfacial Tension

(d) Color

(e) Power Factor

d. Perform minimum pickup voltage tests on trip and close coils.

e. Circuit breaker must be tripped by operation of each protective device. Each protective relay must be serviced. Protective relays must be tested in the housing.

f. Perform insulation resistance tests on each pole to ground and pole to pole.

g. Perform insulation resistance test on all control wiring at 1000 volts DC (do not perform this test on wiring connected to solid state relays).

h. Perform power factor tests on each pole and each bushing equipped with power factor taps.

i. (Optional) Perform overpotential tests on each pole to ground and pole to pole.

Test Values

a. Contact resistance must be determined in microohms. Resistance values must not exceed 500 microohms. Manufacturer must be consulted for acceptable range.

b. Circuit breaker travel and velocity values must be compared to manufacturer's acceptable limits.

c. Insulating liquid tests must comply with manufacturer's recommendations.

635.3 Low Voltage (Air) Circuit Breakers

Visual and Mechanical Inspection.

Perform the following inspections and tests:

a. Inspect for physical damage, cleanliness, and nameplate compliance with one-line diagram.

b. Mechanical operational tests must be made in accordance with manufacturer's instruction manual.

c. Check the cell fit and element alignment.

d. Check tightness of connections.

e. Dashpots must be removed, inspected, cleaned, refilled with proper oil, and tested for operation.

f. Closely inspect the operation of main and arcing contacts of the circuit breaker to ensure that the springs responsible for maintaining primary contact pressure are in good condition.

g. If circuit breakers are a draw out type, closely examine the disconnecting devices at the rear of the circuit breaker. Inspect for any deterioration of springs that might result in high contact resistance of primary disconnects.

Electrical Tests

a. Perform a contact resistance test.

b. Perform an insulation resistance test at 1000 volts DC for one (1) minute from pole to pole and from each pole to ground and across open contacts of each phase.

c. Determine the long time delay by primary injection at three hundred percent (300%) pickup current.

d. Determine the short time pickup and time delay by primary injection of current.

e. Determine the instantaneous pickup current by primary injection.

f. Verify the trip unit reset characteristics.

g. Adjust the final settings in accordance with engineer's prescribed settings, based on a coordination study.

h. Activate the auxiliary protective devices, such as ground fault or under-voltage relays, to ensure operation of shunt trip devices.

i. If the circuit breaker has a charging motor, the springs and other devices associated with this charging motor must be inspected closely. The circuit breaker must be electrically operated to verify the performance of the limit switches responsible for stopping and starting the charging motor.

j. Test circuit breakers with solid state trips according to manufacturer's instructions.

NOTE

Primary injection is recommended to evaluate complete trip circuit operation. Secondary injection can be used for evaluating the electronic portion of the trip unit.

k. (Optional) Minimum pickup current of trip devices must be determined by primary current injection.

Test Values

a. Determine contact resistance in microohmns or voltage drop in millivolts. Values which deviate from adjacent poles or similar breakers by more than fifty percent (50%) must be investigated.

b. Insulation resistance must not be less than fifty (50) megohms.

c. Do not use a megohmmeter on solid state devices.

d. Minimum pickup current, trip times and instantaneous pickup values must be adjusted to engineered settings. Test values must fall within manufacturer's published time-current characteristic tolerance band.

635.4 Low Voltage (Molded Case) Circuit Breakers

Visual and Mechanical Inspection.

Perform the following inspections and tests:

a. Check the circuit breaker for proper mounting, conductor size, and feed designation.

b. Operate circuit breaker to ensure smooth operation.

c. Inspect case for cracks, heat damage, or other defects.

d. Check tightness of connection with a torque wrench in accordance with manufacturer's recommendations.

e. Open all unsealed breakers and check internal components for tightness.

Electrical Tests

a. Measure the contact resistance.

b. Perform a time-current characteristic test by passing three hundred percent (300%) rated current through each pole separately. Trip time must be determined and compared to manufacturer's specifications.

c. Determine the instantaneous pickup current by runup or pulse method. Clearing times must be within four (4) cycles or less.

d. Determine the insulation resistance pole to pole, across pole, and pole to ground. Test voltage must be 1000 volts DC.

Test Values

a. Compare contact resistance to adjacent poles and similar breaker. Deviations of more than fifty (50%) must be investigated.

b. Insulation resistance must not be less than fifty (50) megohms.

c. All trip times must fall within those given in Table 6-4. Circuit breakers exceeding maximum three hundred percent (300%) time (column 5) must be replaced.

d. Instantaneous pickup current levels must be within twenty percent (20%) of manufacturer's published values.

636 Protective Relays

Visual and Mechanical Inspection.

Perform the following inspections and tests:

a. Inspect relays for physical damage, cleanliness, mechanical and electrical operation.

b. Inspect cover gasket, cover glass, condition of spiral spring, disc clearance.

c. Inspect for presence of foreign material, moisture, rust on contacts.

d. Check mechanism for freedom of movement, proper travel and alignment, and tightness of mounting hardware and tap screws.

e. Make all settings in accordance with manufacturer's recommendations.

f. Inspect all shorting contacts for normal operation.

TABLE 6-4

VALUES FOR OVERCURRENT TRIP TEST
(AT 300 PERCENT OF RATED CONTINUOUS CURRENT OF BREAKER)

		Tripping Time, Seconds			
Voltage, Volts	Range of Rated Continuous Current, Amperes	Minimum Thermal Breakers	Minimum Magnetic Breakers	Minimum	Maximum Tripping Time For Cable Protection*
(1)	(2)	(3)	(4)	(5)	(6)
240	15 - 45	3	-	50	100
240	50 - 100	5	-	70	200
600	15 - 45	5	5	80	100
600	50 - 100	5	5	150	200
240	110 - 225	10	5	200	300
600	110 - 225	10	-	200	300
600	250 - 450	25	-	250	300
600	500 - 600	25	10	250	350
600	700 - 1200	25	10	450	600
600	1400 - 2500	25	10	600	750

*These values are based on heat tests conducted by circuit breaker manufacturers on conductors in conduit. (based upon NEMA Standards)

Electrical Tests

a. Perform an insulation resistance test on each circuit to frame (do not perform this test on solid state relays).

b. Perform the following tests on the nominal settings specified by engineering data:

(a) Pickup parameters on each operating element.

(b) Perform timing at three (3) points on performance curves.

(c) Pickup targets and seal in units must operate properly.

(d) Perform special tests as required to check operation of resistant, directional and other elements per manufacturer's instruction manual.

c. Perform phase angle and contribution tests on all phase sensitive relays.

d. Check all protective relays to ensure they are subjected to the correct electrical signals, (amps, volts, watts, etc.).

637 Instrument Transformers and Meters

637.1 Instrument Transformers

Visual and Mechanical Inspection.

Perform the following inspections and tests:

a. Inspect for physical damage.

b. Check mechanical clearance and proper operation of all disconnecting and grounding devices associated with transformers.

c. Verify proper operation of grounding or shorting devices.

Electrical Tests

a. Confirm transformer polarity electrically.

b. Verify connection at secondary Current Transformer (CT) leads by applying a low current through the leads, and check for current contribution at applicable devices.

c. Confirm transformer ratio.

d. Measure insulation resistance of transformer secondary and leads with five hundred (500) volt megohmmeter.

e. Measure transformer primary insulation with applicable overpotential tests.

f. Verify connection of secondary Potential Transformer (PT) leads by applying a low voltage to the leads and checking for voltage contribution at applicable devices.

g. Check for PT secondary load with secondary voltage and current measurements. Make sure load is less than VA of PT.

h. (Optional) Current transformers must have secondary saturation tests done at a minimum of three (3) points below and one (1) point above knee of saturation curve.

i. (Optional) Burden tests to be made at the secondary leads of the CT to assure accurate translation of primary current.

637.2 Meters

Visual and Mechanical Inspection.

Perform the following inspections and tests:

a. Examine all devices for mechanical or electrical damage and wire connection tightness.

b. Check condition of meter face and face gaskets.

Electrical Tests

a. Check calibration of all meters at five points using full scale test instruments that have precision no more than fifty percent (50%) of the instrument being tested.

b. Calibrate watthour meters to one half percent (0.5%).

c. Verify all instrument multipliers.

d. After the meters are calibrated, a calibration curve must be generated to show the accuracy of the meter throughout full range. Test values must be applied to the meter and data taken to plot the curves from 0 to full scale reading.

e. Meter selector switches must be inspected for proper application and operation.

638 Ground Fault and Grounding Systems

638.1 Ground Fault Systems (NEC 230-95)

Visual and Mechanical Inspection.

Perform the following inspections and tests:

a. Inspect for physical damage.

b. Inspect neutral main bonding connection to assure:

(a) Zero sequence system is grounded upstream of sensor.

(b) Ground strap systems are grounded downstream from the sensing device.

(c) Ground connection is made ahead of neutral disconnect link.

c. Inspect control power transformer to ensure adequate capacity for system.

d. Manually operate the monitor panels (if present) for:

(a) Trip tests

(b) No trip tests

(c) Nonautomatic reset; proper operation and test sequence must be recorded.

e. Inspect zero sequence systems for symmetrical alignment of core balance transformers about all current carrying conductors.

f. Verify ground fault device circuit nameplate identification by device operation.

g. Leave pickup and time delay settings as found.

Electrical Test

a. Measure the system neutral insulation resistance to ensure that no shunt ground paths exist.

b. Remove the neutral ground disconnect link. Measure the neutral insulation resistance and replace link.

c. Determine the relay pickup current by performing primary injection at the sensor and operating the circuit interruption device.

d. Test the relay timing by injecting one hundred fifty percent (150%) and three hundred percent (300%) of pickup current into sensor. Total trip time must be electrically monitored.

e. Test the system operation at fifty five percent (55%) rated voltage.

f. If possible, test the zone interlock systems by simultaneously injecting sensor current and monitoring the zone blocking function.

Test Values

a. System neutral insulation must be a minimum of one hundred (100) ohms preferably one (1) megohm or greater.

b. Relay pickup current must be within ten percent (10%) of device dial or fixed setting, and in no case greater than twelve hundred (1200) amperes.

c. Relay timing must be in accordance with manufacturer's published time-current characteristic curves.

638.2 Grounding Systems

Visual and Mechanical Inspection.

Perform the following inspections and tests:

a. Inspect ground system for adequate termination at all devices. Inspect ground and connections to water system. Verify that building steel, water system and ground grid are effectively bonded together (see Item c below).

Electrical Tests

a. On the main grounding electrode or system, perform a fall of potential test per IEEE Standard No. 81, Section 9.04.

b. Perform the two (2) point method test per IEEE No. 81, Section 9.03, to determine the ground resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.

c. Perform high current (100A DC) resistance test of conductors to ground electrode(s).

d. Alternate Method: perform a ground continuity test between main ground system and equipment frame, system neutral and/or derived neutral point. This test must be made by passing a minimum of ten (10) amperes DC current between ground references system and the ground point to be tested. Voltage drop must be measured and resistance calculated by voltage drop method.

Test Values

a. The main ground electrode system resistance to ground must be no greater than five (5) ohms for commercial or industrial systems and one (1) ohm or less for generating or transmission station grounds unless otherwise specified by the engineer.

639 Inspection and Test Procedures For Other Electrical Switchgear

639.1 Battery System

Visual and Mechanical Inspection.

Perform the following inspections and tests:

a. Inspect for physical damage, corrosion, sulphation, disconnection, clean support rails, clean cells and cell connectors antioxidant coated.

b. Check intercell bus link integrity.

c. Inspect lug and intercell connections for integrity.

Electrical Tests

a. Measure system charging voltage and each individual cell voltage.

b. Measure electrolyte specific gravity and level.

c. Perform a discharge test.

Test Values

a. Compare measured values with manufacturer's specifications.

639.2 Surge Arrestors

Visual and Mechanical Inspection.

Perform the following inspections and tests:

a. Inspect for physical damage, such as chipped or fractured porcelain.

b. Inspect ground and discharge counter connections for integrity.

Electrical Tests

a. Perform an insulation power factor test. The test should show similar dielectric loss between similar arrestors.

b. Perform ground continuity test to Ground Grid System. The test should not exceed 0.5 ohms maximum.

c. (Optional) Perform a 60 Hz sparkover test. The results must exceed 1.5 times rating and must not exceed 2.0 rating.

d. (Optional) Perform a Radio Influence Voltage (RIV) test. The test must exceed 1.5 times rating and must not exceed 2.0 rating.

639.3 Engine Generator

Visual and Mechanical Inspection.

Perform the following inspections and tests:

a. Inspect for physical damage.

b. Compare nameplate rating and connection with specifications and one-line diagram.

c. Inspect for proper anchorage and grounding.

d. Verify engine cooling and fuel system integrity.

Electrical Tests

a. Make a dielectric absorption test on generator winding with respect to ground. A polarization index must be determined.

b. Make a phase rotation test to determine compatibility with load requirements.

c. Test protective devices in accordance with applicable sections of these specifications.

d. Test engine shutdown features for:

(a) Low oil pressure

(b) Overtemperature

(c) Overspeed

(d) Other applicable features

e. Perform vibration base line test. Amplitude vs. frequency to be plotted for each main bearing cap.

f. Perform resistive load bank test at one hundred percent (100%) nameplate rating. Loading must be:

(a) 25% rated for 30 minutes

(b) 50% rated for 30 minutes

(c) 75% rated for 30 minutes

(d) 100% rated for 3 hours

NOTE

Record voltage, frequency, load current, oil pressure and coolant temperature during test. Voltage regulation, frequency stability and maximum temperature rise must be calculated.

g. Perform an overpotentional test between winding and ground.

Test Values

a. Dielectric absorption test must be made at test voltages listed in Table 6-1. Polarization index must be made for ten (10) minute durations. Readings less than three (3) must be investigated.

b. Vibration levels must not exceed those listed in Table 7.8.1 (NEMA Standard 7/16/1969).

c. Overpotential test must be made at eighty percent (80%) of twice rated voltage plus one thousand (1000) volts. There must be no insulation breakdown.

d. Load test results must be in accordance with manufacturer's specifications.

639.4 Infrared Scanning of Electrical Equipment

Equipment Requirements

Scan distribution systems with equipment having the ability to detect one (1) degree centigrade rise between subject area and reference areas at 30 degree centigrade. Equipment must detect emitted radiation and convert detected radiation to a visual signal, and must provide photographs (thermograms) of the deficient area as seen on the imaging system.

Visual and Mechanical Inspection.

Perform the following inspections and tests:

a. Inspect the physical, electrical, and mechanical condition.

b. Inspect the bus alignment.

c. Remove all necessary covers prior to scanning.

Equipment to be Scanned Under Load:

Switches, bus duct, switchgear, terminations, cables, cable connections, circuit breakers, terminations, and motor control centers.

Test Values

a. Temperature gradients of 1 degree Centigrade (C) to 3°C indicate a possible deficiency and warrant investigation.

b. Temperature gradients of 4°C to 15°C indicate a deficiency; repair as time permits.

c. Temperature gradients of 16°C and above indicate a major deficiency; secure power and repair as soon as possible.

639.41 Scanning Report

Provide Report Indicating the Following:

a. Problem area (location of "hot spot").

b. The temperature rise between "hot spot" and normal or reference area.

c. The cause of heat rise.

d. Any phase imbalance.

e. An index of areas scanned.

639.5 Lightning Protection System

Visual and Mechanical Inspection.

Perform the following inspections and tests:

a. Check that all air terminals (lightning rods) are interconnected, and that at least two down conductors are installed with their own ground connection.

b. Inspect all air terminals for corrosion and rigid attachment to structure.

c. Examine conductors for corrosion, strong mechanical joints providing good electrical conductivity, and loose or broken fasteners.

d. Check loops, sharp bends (less than 8" radius), and frayed horizontal and vertical conductors.

e. Check for damaged guards and down conductors.

f. Inspect grounding attachments for permanence and corrosion (if practical).

Test Values

a. Check resistance to ground for each conductor.

639.6 Motor Starters, 200 Horsepower and Up

Visual and Mechanical Inspection.

Perform the following inspections and tests:

a. Inspect for broken parts, contact arcing, or any evidence of overheating.

b. Check motor name plate for current rating and controller manufacturer's recommended heater size.

NOTE

Heater size must not be changed without approval from Regional Headquarters.

c. Check line and load connections and heater mounting screws for tightness.

d. Clean all areas of equipment as needed.

Electrical Testing

NOTE

Perform tests every three (3) years.

a. Deenergize and tag circuit.

b. Obtain and review manufacturer's instruction for starter to be tested. (Including the time current characteristic curve.)

c. Perform time/current characteristics test at the appropriate multiple of heater rating.

d. Show both as found and as left.

e. Remove tags and return circuit to service.

Test Values

a. All tests must conform to the appropriate ASTM test procedure and the values used as standards must conform to the manufacturer's and ANSI Standards specifications.

640 SYSTEM TESTS

641 Definition

A system test involves all or part of the switchgear equipment previously mentioned above, tested while working together.

642 Requirements

Upon completion of equipment tests as defined, the system functional tests must be performed. Functionally test each system to ensure total system operation. System functional tests verify the proper interaction of all sensing, processing, and action devices.

All interlocks, safety devices, and fail-safe functions must be tested in addition to design function.

The testing contractor must develop test parameters for evaluating the performance of all integrated components as a complete unit within design requirements, and must propose methods to initiate the sensing devices.

EXHIBIT 6-1

The following is a sample work order describing the equipment to be tested, and the type of test or inspection to be performed.

A. Main Service Switchyard "MSS" consisting of:

Three (3) 110 kV OCB's Nos. 1101, 1102, 1103.

Two (2) 110/12 kV 30 MVA transformers - oil.

Associated Protective relays and instruments.

Associated grounding.

B. 12 kV Switchgear "MS12" consisting of:

Ten (10) air circuit breakers do (Draw Out)

One (1) 15 kV stations transformer.

Three (3) potential transformer.

Nine (9) medium voltage feeders.

Associated protective relays and instruments.

Associated grounding.

C. Five (5) Unit Substations USA, USB, USC, USD, USE, each consisting of:

One (1) medium voltage air switch.

One (1) 12 kV/408 volt, 1500 kVA transformer - dry.

Eight (8) circuit breakers - low voltage air do (Draw Out)

Associated protective relays and instruments.

Associated grounding.

D. Two (2) Compressor Units "CU1" and "CU2" consisting of:

One (1) motor control center CU.

Two (2) 12 kV 2500 H.P. induction motors.

E. Emergency Generator System "EMS" consisting of:

One (1) 1200 amp 480 volt switchboard.

One (1) 1200 amp transfer switch.

One (1) 1000 kW diesel generator.

The following systems must be operationally tested in accordance with Chapter 6 para. 640.

A. High voltage pilot wire differential scheme.

B. Emergency generator system.

All devices and materials to perform the inspection and maintenance must be obtained prior to commencing the work.

A. All instruments required must be available and in proper operating condition.

B. All necessary materials such as solvents, rags and brushes required must be provided. Solvents must be stored in approved containers.

C. All equipment handling devices such as cranes, vehicles, chain falls and other lifting equipment must be available or scheduled. This equipment must be certified safe.

D. All instruction books, calibration curves or other printed material to cover the electrical devices must be available.

E. Data sheets to record all test results must be available before the work is started.

CHAPTER 7

INITIAL SURVEY AND INVENTORY CONTRACT

710 GENERAL

To equip a shop to perform all the tests specified in this handbook would cost more than one hundred thousand dollars. A very high degree of technical expertise would also be essential. Since much of this work is beyond the capabilities of a local post office, it must be contracted out. A number of companies across the country perform this maintenance work. If the work is contracted, care must be taken to ensure that any contract is in agreement with all existing requirements, and that the contractor is actually able to perform all specified work (see 620).

720 INITIAL SURVEY CONTRACT

721 General

Usually the first necessary contract activity, if a new maintenance program is being established, is a comprehensive survey. The survey must be conducted by a company that specializes in such work. The survey will show the adequacy of the wiring diagrams and schematics, and may discover deficiencies in original design or designs that have been developed since installation. The survey must contain a report of findings and recommended solutions. A coordination study may be necessary if modifications have been made in the electrical system, and in facilities with high voltage services or low voltage services 1000 amps and above.

722 Contractor Requirements

The survey contractor must exclusively engage in power engineering switchgear and electrical testing. The contractor must be technically competent to perform the specified work. At least one of the contractor's technical representatives must have a minimum of 4,000 hours actual testing experience.

723 Survey Contract Requirements

The contract must require that the contractor furnish the following documentation:

a. Reproducible one-line electrical drawings using ASA symbols, including distribution diagrams, control wiring, and coordination study.

b. Cables showing manufacturer's voltage class, size, type and length.

c. Breaker type, manufacturer's model and serial numbers, and time current characteristic curves.

d. All PT and CT transformers manufacturer's model and serial number including voltages and ratios.

e. Switchgear, manufacturer's model and serial numbers, and the type of voltage.

f. Relays, induction disc overcurrent, directional overcurrent, thermal overcurrent, over and under voltage, power factor, reverse current, and watt type (a coordination study must provide set points).

g. Lightning and network protector drawings must show all down conductors and tie points, with wire sizes.

h. Distribution power transformers

i. Distribution bus ducts.

j. Switchboards or power distribution panels.

k. Reduced voltage motor starters for chillers.

l. Ground fault relays, a coordination study must be conducted to establish the recommended set points for these relays (if ground fault protection is not provided in the distribution switchgear recommendations must be made on how they can be installed).

m. Grounding drawings showing connection point, type of connection grounding, electrode size, and number of electrodes and the wire size.

n. An inventory list, documenting all the electrical power distribution equipment that will require testing under the terms of the contract.

730 PREVENTIVE MAINTENANCE CONTRACTS

731 Contract Requirements

PM contracts must specify the equipment to be tested and cleaned under the specifications in 430. The scheduled power outages must be specified, and previously agreed to by all responsible parties of the Postal Service.

732 Contractor Requirements

The contractor must be exclusively engaged in power engineering switchgear maintenance and testing. At least one of the contractor's technical representatives must have a minimum of 4,000 hours of actual testing experience.

733 Contractor Responsibilities

733.1 The contractor must furnish all labor, materials, and equipment necessary to perform the work in a first class manner and in accordance with all applicable codes, including those local and State.

733.2 The contractor is responsible for any fees or charges applicable to the project. The contractor must provide all the necessary safety appliances, and must be covered by Workmen's Compensation Insurance and Public Liability Insurance, and indemnify and save harmless the USPS from any liability for damages arising out of the activity of the contractor because of injury to or death of any person or damage to any property. The contractor must coordinate this work with the Manager, Plant and Equipment Engineering or designee.

733.3 During service outage, a complete examination of all equipment involved must be conducted by the contractor's field service engineer. Minor adjustments, as required, must be done at this time. Any necessary major repair to, or replacement of, equipment must be reported, in writing, to the USPS upon completion of the work.

733.4 Work must be performed in accordance with standard practice and the latest factory recommendations.

733.5 Bidders are urged to inspect and fully acquaint themselves with the character of the site and the conditions under which the work will be performed. Failure to do so will not relieve the successful bidder from having to furnish any material or perform any labor that may be required to complete the work in strict accordance with the intent and meaning of specifications without additional cost to the USPS.

733.6 Upon completion of the work, the contractor must guarantee, in writing, that the equipment has been checked and cleaned, that the equipment is adequate for the service intended, that it is properly installed, that it is in good operating condition, and that it is coordinated with other equipment.

733.7 The contractor must submit, in writing, a detailed report on the overall existing conditions found and any corrective work performed. The contractor must include in his report any recommendations concerning further required repairs, and any additional maintenance (to be performed by the USPS) required to keep the equipment in good operating condition.

734 USPS Responsibilities

734.1 Access to the facility must be made available on a reasonably continuous schedule.

734.2 All power switching must be done by USPS personnel, or cleared and supervised by USPS personnel. However, it is the contractor's responsibility to verify that circuits being worked on are deenergized.

734.3 The USPS must allow use of its power for testing and cleaning.

734.4 The USPS engineers and maintenance personnel must furnish access to any existing data, drawings, diagrams, and instructions at the site and pertaining to the apparatus.

734.5 The USPS must provide the services of a representative of the postmaster to help plan work schedules and clear outages with all tenants.

CHAPTER 8

USE AND DISPOSAL OF POLYCHLORINATED BIPHENYLS (PCB)

810 GENERAL

811 Federal

The Environmental Protection Agency (EPA), under authority granted in the Toxic Substances Control Act, has issued revised regulations concerning the manufacture, use, and disposal of the chemical substance known as PolyChlorinated Biphenyls (PCBs). The most common occurrence of PCBs in Postal Service facilities is the dielectric/coolant oil used in transformers. The most recognizable PCB dielectric oil by trade name is "Askarel", manufactured by Monsanto Corporation. Other representative trade names are : Aroclor, Pydraul, Therminol, Pyroclor, Santotherm, Pyralene, Inerteen, Asbestol, Chlorextol, Diachlor, Dykanol, Elemex, Hyvol, No-flamol, Saf-T-Kuhl, Arclor B, Clorinol, clorphen, Eucarel. PCBs may also be present in capacitors and fluorescent ballasts manufactured before 1978, and in dielectric mineral oil not bearing one of the above trade names.

812 USPS Responsibilities

The USPS is responsible for the proper use, storage, and disposition of any PCBs used in its electrical equipment. This responsibility cannot be contracted out. Therefore, local management must ensure that contractors who service PCB equipment comply with the EPA regulations. Postal employees must not service equipment containing PCBs if they might come in direct contact with PCBs. The EPA allows, under certain conditions, PCBs to be disposed of by burning in large boilers. It is Postal Service policy that PCBs will not be disposed of in its boilers.

813 References

813.1 Sources

This chapter gives an overview and practical approach to PCB regulations and requirements as they apply to most Postal Service installations. If you have unique problems or extensive quantities of PCBs in use or stored, you may wish to have copies of the regulations on site. However, these regulations have not been published, as yet, in one document. You will need copies of the following material from the Federal Register:

Vol. 44, No. 106/Thursday, May 31, 1979 pp. 31515 through 31568

Vol. 47, No. 88/Thursday, May 6, 1982 pp. 19527

Vol. 47, No. 165/Wednesday, August 25, 1982 pp. 37342 through 37360

For additional background information, you may wish to have a copy of Federal Register:

Vol. 46, No. 46/Tuesday, March 10, 1981 pp. 16090 through 16098

EPA's Final PCB Ban Rule: Questions and Answers to Help You Meet These Requirements (Revised Aug., 1983)

813.2 Supply

Copies of the Federal Register are available from the Library, USPS Headquarters, Washington D.C., 20260, regional EPA Offices (see Exhibit 8-1), or local university and metropolitan libraries. The above material, except the Questions and Answers, is very time consuming to read; therefore, specific questions can be answered most efficiently by calling your Regional EPA Office (see Exhibit 8-1).

814 Definitions

The following definitions are crucial to understanding the precise meaning of PCB legislation.

a. PCB Item: Any article, container, or equipment that contains PCBs at a concentration of 50 parts per million (PPM) or greater.

b. PCB Contaminated Electrical Equipment: Any electrical equipment (such as transformers, capacitors, circuit breakers, reclosers, voltage regulators, switches, cables, etc.) that contain 50 PPM PCB, but less than 500 PPM PCB. Oil-filled electrical equipment other than circuit breakers, reclosers, and cable whose PCB concentration is unknown must be assumed to be PCB contaminated electrical equipment.

c. PCB Transformer: Any transformer that contains 500 PPM PCB or greater.

d. Small Capacitor: A capacitor which contains less than 3 lbs. of dielectric fluid. If the weight of dielectric fluid is unknown, use the following criteria:

If the total volume of the capacitor is less than 100 cubic inches, it is a small capacitor.

If the volume is between 100 and 200 cubic inches and the capacitor weighs less than 9 lbs, it is a small capacitor.

If the volume is greater than 200 cubic inches, it is not a small capacitor.

e. Totally Enclosed Manner: A manner that results in no PCB exposure to humans or the environment.

820 PROHIBITED ACTIVITIES

821 Transportation

PCB or PCB items must not be used or transported in commerce except in a totally enclosed manner. Transformers which are intact and not leaking are considered totally enclosed. PCBs or PCB items may not be exported for disposal.

NOTE

Transporting for disposal is addressed later.

822 Use

Waste oil which contains any detectable concentration of PCBs may not be used as a sealant, coating, dust control agent, or in herbicides and pesticides.

Any servicing of PCB transformers that requires the removal of the transformer coil from the transformer casing is prohibited.

Servicing electromagnets, switches and voltage regulators with a PCB concentration of 500 PPM or greater which requires removal and rework of the internal components is prohibited.

Dielectric fluid concentrations of greater than 500 PPM must never be added to PCB-contaminated electrical equipment, non-PCB transformers, or to dielectric fluids of less than 500 PPM PCB concentration.

830 PERMITTED ACTIVITIES

831 Use

PCB transformers may be used for the remainder of their useful lives provided that a quarterly inspection for leaks is made. If a PCB transformer is found to have a leak resulting in any quantity of PCBs running off or about to run off the external surface, the transformer must be repaired or replaced. Cleanup of leaking material must start within 48 hours. Disposal of leaking material must be in accordance with EPA regulations (discussed in 813), and records of the inspections must be kept in accordance with Table B of EPA Regulations.

PCBs of any concentration may be used in large capacitors. After October 1, 1988 large PCB capacitor must be located in a restricted access (i.e., fenced or walled and locked) area.

Circuit breakers, reclosers, and cable containing PCBs at any concentration may continue to be used. However, they may be serviced only with dielectric fluid containing less than 500 PPM.

Small capacitors and fluorescent ballasts containing PCBs of any concentration may continue to be used.

A PCB transformer may be reclassified to PCB contaminated electrical equipment or to a non-PCB transformer by draining and refilling and/or otherwise servicing. Reclassification requires testing after three months to show that the PCB level is below 500 PPM for PCB contaminated electrical equipment and 50 PPM for a non-PCB transformer. It is Postal Service policy that this work must be done by a competent contractor and not by USPS maintenance personnel.

Electromagnets, switches and voltage regulators may be converted to PCB contaminated electrical equipment or to a non-PCB classification by draining and refilling and/or otherwise servicing the equipment. Filtration for about 1 year is required to remove residual PCB.

PCBs removed from electrical equipment must be captured and either reused or disposed of as discussed in 850.

Any dielectrical fluid containing 50 PPM or greater which is used for servicing must be stored in accordance with EPA Regulations discussed in 813.

840 MARKING REQUIREMENTS

The following items must be marked by a label (see figure 8-1, Exhibit 8-2). If the label is too large for the item use figure 8-2.

a. Any container which contains PCBs or items which have been in contact with PCBs.

b. PCB Transformers.

c. PCB large high voltage capacitors (i.e., more than three lbs. of dielectric fluid and operating below 2000 volts).

d. Electric motors, hydraulic systems, and heat transfer systems which use PCBs in concentrations above 50 PPM.

NOTE

PCB contaminated electrical equipment does not have to be marked.

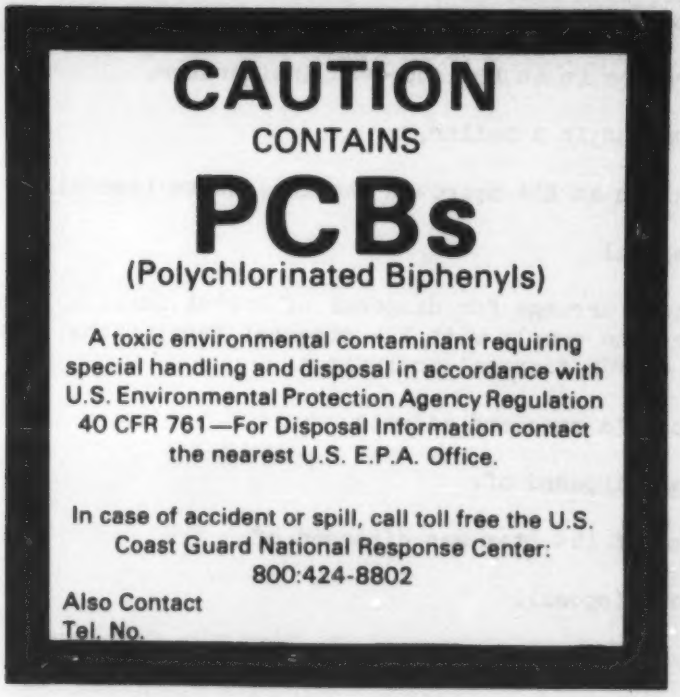

CAUTION
CONTAINS
PCBs
(Polychlorinated Biphenyls)
A toxic environmental contaminant requiring special handling and disposal in accordance with U.S. Environmental Protection Agency Regulation 40 CFR 761—For Disposal Information contact the nearest U.S. E.P.A. Office.
In case of accident or spill, call toll free the U.S. Coast Guard National Response Center: 800:424-8802
Also Contact
Tel. No.

Figure 8-1

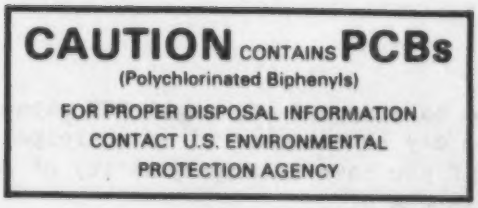


Figure 8-2

850 DISPOSAL OF PCBs AND PCB ITEMS

851 Disposal Methods

The EPA regulations allow three methods of disposal of PCBs and materials which have come in contact with PCBs (not all methods are allowable for all forms of PCBs). These methods are:

a. Incineration in an EPA approved incinerator.

b. Incineration in a boiler.

c. Disposal in an EPA approved chemical waste landfill.

852 Contractor Disposal

Local management must arrange for disposal of Postal Service PCBs and PCB items through contractors who comply with EPA disposal regulations. Local management must keep records of PCB disposal including:

a. Contractor's name and address.

b. What was disposed of.

c. How much of the item was disposed of.

d. Dates of disposal.

e. Method of disposal.

f. Name and location of the disposal site.

NOTE

The Postal Service will not incinerate any PCBs in Postal Service boilers.

853 Exceptions

If only a few items are to be disposed of, small PCB capacitors and PCB fluorescent light ballasts may be disposed of as municipal solid waste. Contact your Regional EPA Office if you have a large quantity of small PCB Capacitors or fluorescent ballasts to dispose of.

854 Cleaning Materials

Solid materials used for cleaning up PCB leaks and spills must be placed in containers and disposed of in a chemical waste landfill approved by the Regional EPA.

855 Storage for Disposal

855.1 Need for Storage

Because there are very few EPA approved incinerators or chemical waste landfills, it may be necessary to store PCBs and PCB items prior to disposal.

855.2 Container Requirements

Containers used for storage of liquid PCBs must comply with the shipping container specification of the Department of Transportation, Specification 5, "Container Without Removable Head", or Specification 2S, "Polyethelene Containers", not leaking and structurally undamaged PCB large high voltage capacitors and PCB contaminated transformers that have not been drained of free flowing dielectric fluid may be stored on pallets next to an "approved" storage facility within a Postal Service facility. PCB transformers must first be flushed three times with a solvent containing less than 50 PPM PCB and equal to 10% of the transformer's liquid capacity. The solvent may be reused until its PCB level reaches 50 PPM and then disposed of as required of PCBs.

855.3 Storage Facility Requirements

The storage facility must not be located at a site that is below the 100 year flood water elevation, and must have:

a. Adequate roof and walls to prevent rain water from reaching the stored PCBs and PCB items.

b. An adequate floor with continuous curbing (minimum 6 inches high) providing a containment volume equal to at least two times the internal volume of the largest PCB articles or containers stored therein, whichever is greater.

c. No drain valves, floor drains, expansion joints, sewer lines or other openings that would permit liquids to flow from the curbed area.

d. Floors and curbing constructed of continuous smooth and impervious materials.

NOTE

Stored materials must be checked at least every 30 days for leaks.

860 REQUIRED RECORDS

Records must be developed for items used or stored totalling 99.4 or more pounds of PCBs contained in PCB container(s), for one or more PCB transformers, or 50 or more PCB large, high or low voltage capacitors. Records must include the use and disposition of PCBs and PCB items. The records form the basis for a document

prepared for each facility by July 1 of each year covering the previous calendar year and must be retained for five years after the facility ceases using or storing the PCBs and PCB items. The records must include:

a. Dates when PCBs and PCB items are removed from service, are placed into storage for disposal and are placed into transport for disposal. Quantities of PCBs and PCB items must be indicated using the following breakdown:

   (a) Total weight in kilograms of any PCBs and PCB items in PCB containers including, identification of container contents such as liquids and capacitors.

   (b) Total number of PCB transformers and total weight in kilograms of any PCBs contained in the transformers.

   (c) Total number of PCB large high or low voltage capacitors.

b. For PCBs and PCB items removed from service, the location of the initial disposal or storage facility and the name of the owner or operator of the facility.

c. Total quantities of PCBs and PCB items remaining in service at the end of the calendar year using the following breakdown:

   (a) Total weight in kilograms of any PCBs and PCB items in PCB containers, including identification of container contents such as liquids and capacitors.

   (b) Total number of PCB transformers and total weight in kilograms of any PCBs contained in the transformers.

   (c) Total number of PCB large high or low voltage capacitors.

NOTE

See Exhibit 8-3 for the required records of PCB transformers.

EXHIBIT 8-1

EPA REGIONAL OFFICES

Region I
Connecticut, Main, Massachusetts, New Hampshire, Rhode Island, and Vermont
John F. Kennedy Federal Building
Room 2303
Boston, Massachusetts 02203-0001
(617) 223-0585

Region II
New York, New Jersey, Puerto Rico, Virgin Islands, and Canal Zone
Federal Office Building
26 Federal Plaza
New York, New York 10007-0012
(212) 264-0545

Region III
Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia
Curtis Building
Sixth and Walnut Streets
Philadelphia, Pennsylvania 19106-3395
(215) 597-7668

Region IV
Alabama, Florida, Georgia, Kentucky Mississippi, North Carolina, South Carolina, and Tennessee
345 Courtland St. NE
Atlanta, Georgia 30308-2401
(404) 881-3864

Region V
Illinois, Indiana, Minnesota, Michigan, Ohio, and Wisconsin
230 South Dearborn
Chicago, Illinois 60604-1590
(312) 353-2291

Region VI
Arkansas, Louisiana, New Mexico, Oklahoma, and Texas
First International Building
1201 Elm Street
Dallas, Texas 75270-2180
(214) 767-9772

Region VII
Iowa, Kansas, Missouri, and Nebraska
1735 Baltimore Avenue
Kansas City, Missouri 64108-1304

Region VIII
Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming
1860 Lincoln Street
Denver, Colorado 80295-0699
(303) 837-3926

Region IX
Arizona, California, Hawaii, Nevada, Guam, American Samoa, and Trust Territory of the Pacific
100 California Street
San Francisco, California 94111-5402
(415) 974-8389

Region X
Alaska, Idaho, Oregon, and Washington
1200 Sixth Avenue
Seattle, Washington 98101-3188
(206) 442-2643

EXHIBIT 8-2

The following formats must be used for marking:

a. Large PCB Label M_L. Label M_L must be as shown in Figure 8-1, letters and striping on a white or yellow background and must be sufficiently durable to equal or exceed the life (including storage for disposal) of the PCB article, PCB equipment, or PCB container. The size of the label must be at least 15.25 cm. (6 inches) on each side. If the PCB article or PCB equipment is too small to accomodate this size, the label may be reduced in size proportionately down to a minimum of 5 cm. (2 inches) on each side.

b. Small PCB Label M_L. Label M_L must be as shown in Figure 8-2, letters and striping on a white or yellow background, and must be sufficiently durable to equal or exceed the life (including storage for disposal) of the PCB article, PCB equipment, or PCB container. The label must be a rectangle 2.5 by 5 cm. (1 inch by 2 inches). If the PCB article or PCB equipment is too small to accommodate this size, the label may be reduced in size proportionately down to a minimum of 1 by 2 cm. (0.4 by 0.8 inches).

These labels should be purchased locally. They are also available from:

Industrial Safety
1390 Neubrecht Rd.
Lima, OH 45801-3196
(419) 227-6030

Seton Name Plate Corp.
P.O. Drawer 1334
New Haven, CT 06505-1334
(203) 772-2520

EXHIBIT 8-3

REQUIRED RECORDS FOR PCB TRANSFORMERS

A. Each transformer's location.

B. The date of each visual inspection and the date that a leak was discovered, if different from the inspection date.

C. The person performing the inspection.

D. The location of any leak(s).

E. An estimate of the amount of dielectric fluid released from any leak.

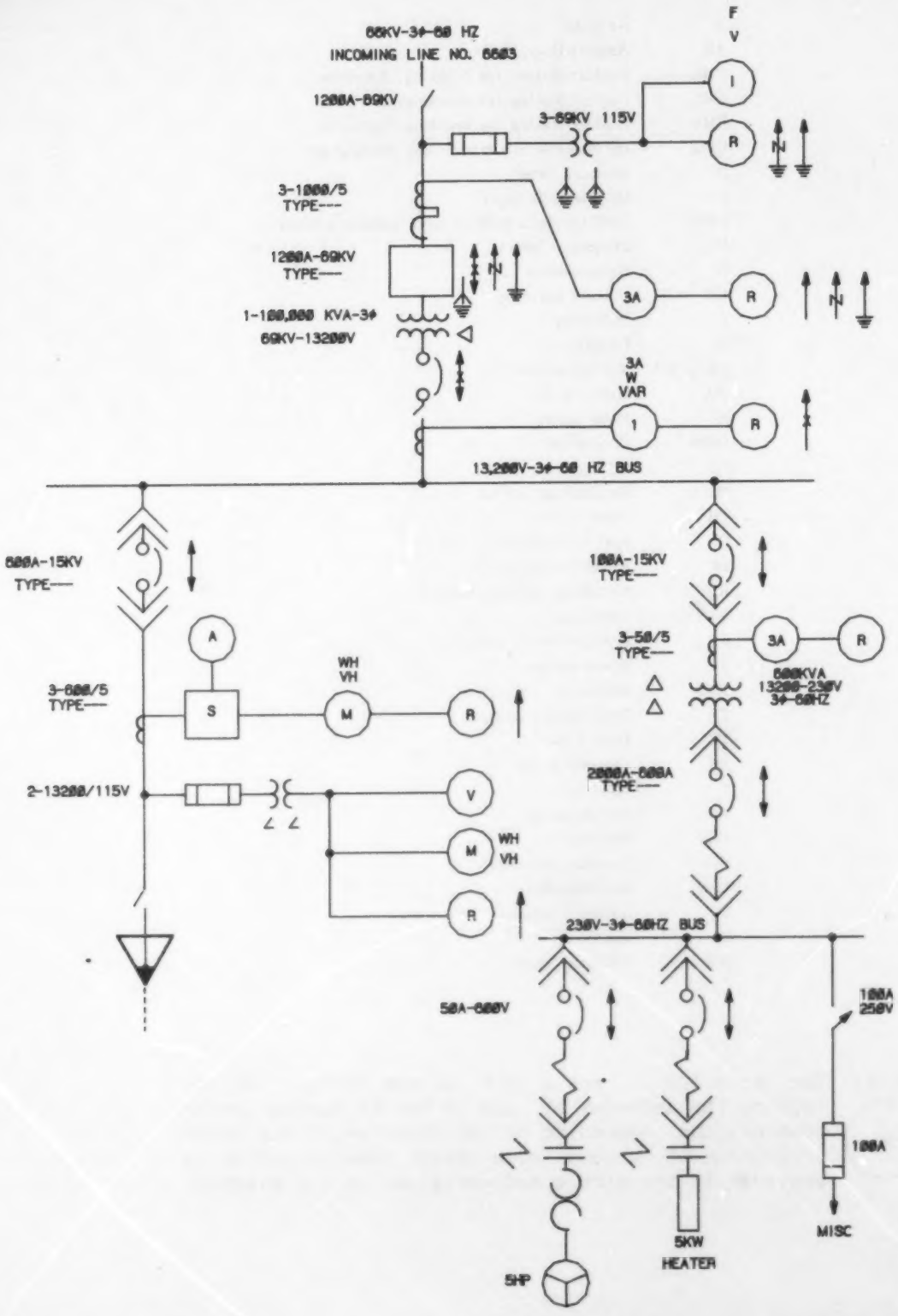
F. The date of any cleanup, containment, repair, or replacement.

G. A description of any cleanup, containment, or repair performed.

H. The results of any containment and daily inspection required for uncorrected active leaks.

A	Ammeter
AH	Ampere-Hour Meter
CMA	Contact-Making (or breaking) Ammeter
CMC	Contact-Making (or breaking) Clock
CMV	Contact-Making (or breaking) Voltmeter
CRO	Oscilloscope or Cathode Ray Oscillograph
D	Demand Meter
DB	DB (decibel) Meter
DBM	DBM (decibels reffered to 1 milliwatt) Meter
F	Frequency Meter
G	Galvanometer
GD	Ground Detector
I	Indicating
M	Integrating
μA or UA	Microammeter
MA	Milliammeter
N	Noise meter
OHM	Ohmmeter
OP	Oil Pressure
OSCG	Oscillograph, string
PH	Phase Meter
PI	Position Indicator
PF	Power-Factor meter
RD	Recording Demand meter
REC	Recording
RF	Reactive-Factor meter
S	Synchroscope
TLM	Telemeter
T	Temperature meter
TT	Total Time
VH	Varhour meter
V	Voltmeter
VA	Volt-Ammeter
VAR	Varmeter
VI	Volumne Indicator
VOM	Volt-Ohm Meter
VU	Standard volumne indicator
W	Wattmeter
WH	Watthour Meter

NOTE: The asterisk is not a part of the symbol. Always replace the asterisk by one of the following letter combinations depending on the function of the meter or instrument, unless some other identification is provided in the circle and explained on the diagram.


66KV-3φ-60 HZ
INCOMING LINE NO. 6603
1200A-69KV
3-69KV 115V
F
V
I
R
3-1000/5
TYPE---
1200A-69KV
TYPE---
1-100,000 KVA-3φ
69KV-13200V
3A
R
3A
W
VAR
1
R
13,200V-3φ-60 HZ BUS
600A-15KV
TYPE---
A
S
WH
VH
M
R
3-600/5
TYPE---
2-13200/115V
V
M
WH
VH
R
100A-15KV
TYPE---
3-50/5
TYPE---
3A
R
600KVA
13200-230V
3φ-60HZ
2000A-600A
TYPE---
230V-3φ-60HZ BUS
50A-600V
100A
250V
100A
MISC
5KW
HEATER
5HP

ARRESTER:

GENERAL (LIGHTNING OR SURGE)

CARBON BLOCK

ELECTROLYTIC OR ALUMINUM CELL

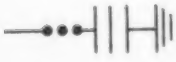
HORN GAP

PROTECTIVE GAP

SPHERE GAP

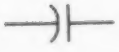
VALVE OR FILM ELEMENT

MULTI-GAP, GENERAL

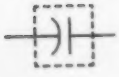


GAP AND VALVE, PLUS GROUND

CAPACITOR:

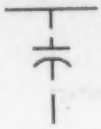


GENERAL



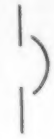
SHIELDED

ADJUSTABLE OR VARIABLE

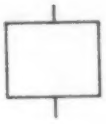


SHUNT CAPACITOR

CIRCUIT BREAKER:



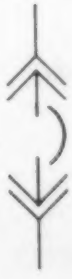
AIR OR GENERAL



OIL OR OTHER TYPES

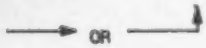
WITH THERMAL OVERLOAD DEVICE

WITH MAGNETIC OVERLOAD DEVICE



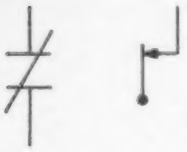
DRAWOUT TYPE

CONTACT, ELECTRICAL:

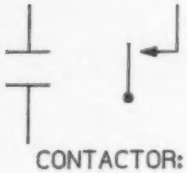


OR

ADJUSTABLE OR SLIDING CONTACT

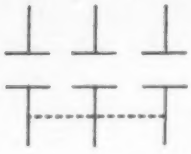


CLOSED CONTACT (BREAK)



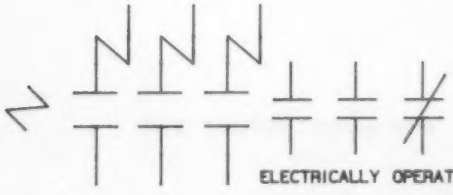
OPEN CONTACT (MAKE)

CONTACTOR:



3-POLE MANUALLY OPERATED

ELECTRICALLY OPERATED
1-POLE WITH SERIES BLOWOUT
COIL



ELECTRICALLY OPERATED 3-POLE
WITH SERIES BLOWOUT COILS, 2 OPEN
AND 1 CLOSED AUXILIARY CONTACTS

ELECTRICALLY OPERATED 1-POLE
WITH SHUNT BLOWOUT COIL

CURRENT LIMITER FOR POWER CABLE:

GENERAL

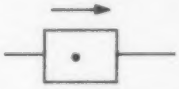
DIRECTION OF POWER, SIGNAL FLOW:

OR

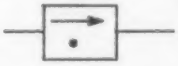
ONE WAY

OR

BOTH WAYS



OR

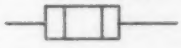


ONE-WAY CIRCUIT ELEMENT, GENERAL
•INDICATES ELEMENT

ELEMENT, THERMAL:

GENERAL

FUSE:



GENERAL

GROUND:

GENERAL

INDUCTOR:

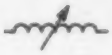
OR

GENERAL

MAGNETIC CORE

TAPPED

ADJUSTABLE


VARIABLE

SHUNT

MACHINE, ROTATING:

BASIC

GENERATOR, GENERAL

MOTOR, GENERAL

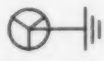
FIELD, GENERATOR OR MOTOR

WINDING SYMBOLS:

1-PHASE

2-PHASE

3-PHASE WYE (UNGROUNDED)


3-PHASE WYE (GROUNDED)

3-PHASE DELTA

RECTIFIER:

POWER RECTIFIER

RELAY:

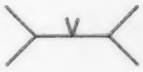
BASIC

RELAY PROTECTIVE FUNCTIONS:

OVERCURRENT

DIRECTIONAL OVERCURRENT

DIRECTIONAL RESIDUAL OVERCURRENT

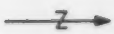


UNDER VOLTAGE

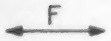
POWER DIRECTIONAL

BALANCED CURRENT

DIFFERENTIAL CURRENT



DIRECTIONAL DISTANCE



OVERFREQUENCY

OVERTEMPERATURE

PHASE BALANCE

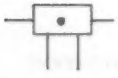
RESISTOR:

OR

GENERAL

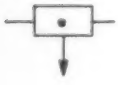
ADD IDENTIFICATION

OR



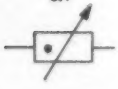
TAPPED

OR



ADJUSTABLE

OR



VARIABLE

SHIELDING:

GENERAL

ENCLOSING

SWITCH:

SINGLE THROW, GENERAL

DOUBLE THROW, GENERAL

KNIFE SWITCH, GENERAL

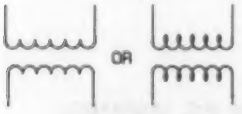
SWITCH WITH HORN GAP

SELECTOR, GENERAL

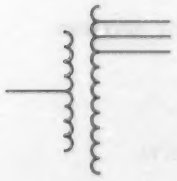
TERMINATION:

CABLE TERMINATION

TRANSFORMER:



GENERAL



WITH TAPS, 1 PHASE

3-PHASE, OPEN-DELTA

3-PHASE, WYE, OR STAR, UNGROUNDED

3-PHASE, WYE, GROUNDED NEUTRAL

3-PHASE 4-WIRE UNGROUNDED

3-PHASE, SCOTT OR T

WIRING

ELECTRIC CONDUCTORS

CABLE UNDERGROUND OR IN CONDUIT

FUTURE CONDUCTORS

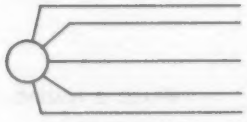
SPLICED CONDUCTORS OR CHANGE OF TYPE OR SIZE

JUNCTION OF CONNECTED PATHS

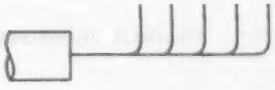
CROSSING OF CONDUCTORS NOT CONNECTED

GROUPING OF LEADS

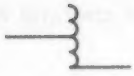
OR

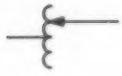


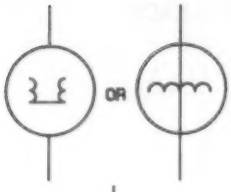
OR



OR


AUTOTRANSFORMER, 1-PHASE


ADJUSTABLE



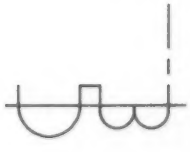
1-PHASE INDUCTION VOLTAGE REGULATOR

3-PHASE INDUCTION VOLTAGE REGULATOR

1-PHASE, 2 WINDING TRANSFORMER

POLYPHASE TRANSFORMER

CURRENT TRANSFORMER


BUSHING TYPE CURRENT TRANSFORMER

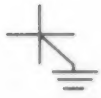
POTENTIAL TRANSFORMER

WINDING CONNECTION SYMBOLS:

2-PHASE 3-WIRE, UNGROUNDED

2-PHASE 3-WIRE, GROUNDED

2-PHASE 4-WIRE


2-PHASE 5-WIRE, GROUNDED

3-PHASE 3-WIRE, DELTA OR MESH

3-PHASE 3-WIRE, DELTA, GROUNDED

3-PHASE 4-WIRE, DELTA, UNGROUNDED

3-PHASE 4-WIRE, DELTA, GROUNDED

APPENDIX B
ROGERS RATIO METHOD

Gas Ratios and Code Numbers

RATIO	GAS RATIO	GASES	RANGE	CODE
1	$\frac{CH_4}{H_2}$	METHANE / HYDROGEN	less than 0.1	3
			0.1 to 1.0	0
			greater than 1.0 less than 3.0	1
			greater than 3.0	2
2	$\frac{C_2H_6}{CH_4}$	ETHANE / METHANE	less than 1.0	0
			greater or equal to 1.0	1
3	$\frac{C_2H_4}{C_2H_6}$	ETHYLENE / ETHANE	less than 1.0	0
			greater than or equal to 1.0 but less than 3.0	1
			greater than or equal to 3.0	2
4	$\frac{C_2H_2}{C_2H_4}$	ACETYLENE / ETHYLENE	less than 0.1	0
			equal to or greater than 0.1 but less than 3.0	1
			greater or equal to 3.0	2

NOTE

If division by zero, the Ratio is zero

INTERPRETATIONS

RATIO 1	RATIO 2	RATIO 3	RATIO 4	
0	0	0	0	Normal Deterioration
3	0	0	0	Partial Discharge (Corona) of Low Density - Possibly Tracking
1	0	0	0	Slight Overheating - below 150°C
2	0	0	0	Slight Overheating - below 150°C
1	1	0	0	Moderate Overheating - 150°C-200°C
2	1	0	0	Moderate Overheating - 150°C-200°C
0	1	0	0	Severe Overheating - 200°C-300°C
0	0	1	0	Insulated Conductor Overheating
1	0	1	0	Overheating of Copper Due to Eddy Current (Circulating Current)
1	0	2	0	Overheating - Joints or Bad Contacts, Core and Tank Circulating Currents
0	0	0	1	Flashover Without Power Follow-through
0	0	1	1	Low Energy Discharge: Continuous Sparking
0	0	1	2	Low Energy Discharge: Continuous Sparking
0	0	2	1	High Energy Discharge: Arc With Power Follow-through
0	0	2	2	High Energy Discharge: Arc With Power Follow-through
3	0	0	1	Partial Discharge of Low Energy - Possibly With Tracking
3	0	0	2	Partial Discharge of Low Energy - Possibly With Tracking

Generally if the ratio CO_2/CO is greater than 11, there is an indication of higher than normal temperatures occurring in the vicinity of cellulosic insulation.

APPENDIX C

GLOSSARY

NOTE

The following definitions are for use with the National Electrical Safety Code. For other use, and for definitions not contained herein, see ANSI/IEEE Std 100-1977, IEEE Standard Dictionary of Electrical and Electronics Terms (see Chapter 3.)

Automatic: Self acting, operating by its own mechanism when actuated by some impersonal influence, for example, a change in current strength; not manual; without personnel intervention. Remote control that requires personal intervention is not automatic, but manual.

Bonding: The electrical interconnecting of conductive parts, designed to maintain a common electrical potential.

Cable: A conductor with insulation, or a stranded conductor with or without insulation and other coverings (single-conductor cable) or a combination of conductors insulated from one another (multiple-conductor cable).

Cable Jacket: A protective covering over the insulation, core, or sheath of a cable.

Cable Sheath: A conductive protective covering applied to cables. A cable sheath may consist of multiple layers one or more of which is conductive.

Cable Terminal: A device which provides insulated egress for the conductors. Also termination.

Circuit: A conductor or system of conductors through which an electric current is intended to flow.

Circuit Breaker: A switching device capable of making, carrying, and breaking currents under normal circuit conditions and also making, carrying for a specified time, and breaking currents under specified abnormal conditions such as those of short circuit.

Conductor: A material, usually in the form of a wire, cable, or bus bar, suitable for carrying an electric current.

Conductor Shielding: An envelope which encloses the conductor of a cable and provides an equipotential surface in contact with the cable insulation.

Conduit: A structure containing one or more ducts. Conduit may be

designated as iron pipe conduit, tile conduit, etc. If it contains one duct only it is called single duct conduit; it if contains more than one duct it is called multiple duct conduit, usually with the number of ducts as a prefix, for example, two duct multiple conduit.

Conduit System: Any combination of duct, conduit, conduits, manholes and vaults joined to form an integrated whole.

Covered Conductor: A conductor covered with a dielectric having no rated insulating strength or having a rated insulating strength less than the voltage of the circuit in which the conductor is used.

Current-carrying Part: A conducting part intended to be connected in an electric circuit to a source of voltage. Non-current-carrying parts are those not intended to be so connected.

Deenergized: Free from any electrical connection to a source of potential difference and from electric charge; not having a potential different from that of the earth. The term is used only with reference to current-carrying parts which are sometimes energized (alive). Also dead.

Designated Person: A qualified person designated to perform specific duties under the conditions existing. Also designated employee.

Disconnecting or Isolating Switch: A mechanical switching device used for changing the connections in a circuit, or for isolating a circuit or equipment from a source of power. It is required to carry normal load current continuously, and also abnormal or short-circuit current for short intervals as specified. It is also required to open or close circuits either when negligible current is broken or made, or when no significant change in the voltage across the terminals of each of the switch poles occurs. Also disconnector, isolator.

Duct: A single enclosed raceway for conductors or cable.

Effectively Grounded: Intentionally connected to earth through a ground connection or connections of sufficiently low impedance and having sufficient current-carrying capacity to prevent the build up of voltages which may result in undue hazard to connected equipment or to persons.

Electric Supply Equipment: Equipment which produces, modifies, regulates, controls, or safeguards a supply of electric energy. Also supply equipment.

Electric Supply Lines: Those conductors, and their necessary supporting or containing structures, used to transmit electric energy. Lines of more than 400 volts are always supply lines within the meaning of the rules, and those of less than 400 volts may be considered as supply lines, if so run and operated throughout. Also supply lines.

Electric Supply Station: Any building, room, or separate space within which electric supply equipment is located and the interior of which is accessible, as a rule, only to qualified persons. This includes generating stations and substations, including their associated generator, storage battery, transformer, and switchgear rooms, or enclosures, but does not include facilities such as pad mounted equipment and installations in manholes and vaults.

Enclosed: Surrounded by case, cage, or fence and designed to protect the contained equipment and minimize the possibility, under normal conditions, of dangerous approach or accidental contact by persons or objects.

Energized: Electrically connected to a source of potential difference, or electrically charged so as to have a potential significantly different from that of earth in the vicinity. Also alive or live.

Equipment: A general term including fittings, devices, appliances, fixtures, apparatus, and similar terms used as part of or in connection with an electric supply or communication system.

Explosion-proof Apparatus: Apparatus enclosed in a case that is capable of withstanding an explosion of a specified gas or vapor which may occur within it and of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes, or explosion of the gas or vapor within, and which operates at such an external temperature that a surrounding flammable atmosphere will not be ignited thereby.

Exposed: Not isolated or guarded.

Fireproofing (of cables): The application of a fire-resistant covering.

Grounded: Connected to or in contact with earth or connected to some extended conductive body serving instead of the earth.

Grounded Conductor: A conductor which is intentionally grounded, either solidly or through a non-interrupting current-limiting device.

Grounded System: A system of conductors in which at least one conductor or point is intentionally grounded, either solidly or through a non-interrupting current-limiting device.

Grounded Effectively: See: effectively grounded.

Grounding Conductor: A conductor which is used to connect the equipment or the wiring system with a grounding electrode or electrodes.

Guarded: Covered, fenced, enclosed, or otherwise protected, by means of suitable covers or casings, barrier rails or screens, or mats or

platforms, designed to minimize the possibility, under normal conditions, of dangerous approach or accidental contact by persons or objects.

NOTE

Wires which are insulated, but not otherwise protected, are not considered as guarded.

Insulated: Separated from other conducting surfaces by a dielectric (including air space) offering a high resistance to the passage of current.

NOTE

When any object is said to be insulated, it is understood to be insulated for the conditions to which it is normally subjected. Otherwise, it is, within the purpose of these rules, uninsulated.

Insulated Conductor: A conductor covered with a dielectric (other than air) having a rated insulating strength equal to or greater than the voltage of the circuit in which it is used.

Insulation (as applied to cable). That which is relied upon to insulate the conductor from other conductors or conducting parts or from ground.

Insulation Shielding: An envelope which encloses the insulation of a cable and provides an equipotential surface in contact with the cable insulation.

Insulator: Insulating material in a form designed to support a conductor physically and electrically separate it from another conductor or object.

Isolated: Not readily accessible to persons unless special means for access are used.

Isolator: See: Disconnecting or Isolating Switch.

Jacket: A protective covering over the insulation, core, or sheath of a cable.

Low Voltage Protection: The effect of a device operative on the reduction or failure of voltage so as to cause and maintain the interruption of power supply to the equipment protected.

Manhole: A subsurface enclosure which personnel may enter to install, operate, and maintain submersible equipment and cable.

Manhole Cover: A removable lid which closes the opening to a manhole

or similar subsurface enclosure.

Manhole Grating: A grid providing ventilation and a protective cover for a manhole opening.

Manual: Capable of being operated by human intervention.

Network Protectors: A network protector is an air circuit breaker equipped with specialized relays that sense network circuit conditions and command the circuit breaker to either open or close. There is no separate power source for control. All control power is taken from the system.

Open Conductor: A type of electric supply or communication. Also open wire.

Pad-mounted Equipment: A general term describing enclosed equipment, the exterior of which enclosure is at ground potential, positioned on a surface-mounted pad.

Qualified: Having adequate knowledge and thorough training of the installation, construction, or operation of apparatus and the hazards involved.

Raceway: Any channel designed expressly and used solely for holding conductors.

Switch: A device for opening and closing or for changing the connection of a circuit. In these rules, a switch is understood to be manually operable, unless otherwise stated.

Switchboard: A type of switchgear assembly consisting of one or more panels with electric devices mounted thereon, and associated framework.

Tag: Accident prevention tag (DANGER, PEOPLE AT WORK, etc) of a distinctive appearance used for the purpose of personnel protection to indicate that the operation of the device to which it is attached is restricted.

Transformer Vault: An isolated enclosure either above or below ground with fire-resistant walls, ceiling, and floor, in which transformers and related equipment are installed, and which is not continuously attended during operation. See also: vault.

Utility: An organization responsible for the installation, operation or maintenance of electric supply or communication systems.

Utilization Equipment: Equipment, devices, and connected wiring utilizing electric energy for mechanical, chemical, heating, lighting, testing or similar purposes and not a part of supply equipment, supply lines, or communication lines.

Vault: An enclosure above or below ground which personnel may enter to install, operate, or maintain equipment or cable.

Voltage: The effective root mean square (rms) potential difference between any two conductors or between a conductor and ground. Voltages are expressed in nominal values unless otherwise indicated. The nominal voltage of a system or circuit is the value assigned to a system or circuit of a given voltage class for the purpose of convenient designation. The operating voltage of the system may vary above or below this value.

Voltage Of Circuit Not Effectively Grounded: The highest nominal voltage available between any two conductors of the circuit.

NOTE

If one circuit is directly connected to and supplied from another circuit of higher voltage (as in the case of an autotransformer), both are considered as of the higher voltage, unless the circuit of the lower voltage is effectively grounded, in which case its voltage is not determined by the circuit of higher voltage. Direct connection implies electric connection as distinguished from connection merely through electromagnetic or electrostatic induction.

Voltage Of A Constant Current Circuit: The highest normal full load voltage of the current.

Voltage Of An Effectively Grounded Circuit: The highest nominal voltage available between any conductor of the circuit and ground unless otherwise indicated.

Voltage To Ground Of:

a. **A Ground Circuit:** The highest nominal voltage available between any conductor of the circuit and that point or conductor of the circuit which is grounded.

b. **An Undergrounded Circuit:** The highest nominal voltage available between any two conductors of the circuit concerned.

Voltage To Ground Of A Conductor Of:

a. **A Grounded Circuit:** The nominal voltage between such conductor and that point or conductor of the circuit which is grounded.

b. **An Ungrounded Circuit:** The highest nominal voltage between such conductor and any other conductor of the circuit concerned.

Wire Gauges: Throughout these rules the American Wire Gauge (AWG), formerly known as Brown & Sharpe (B&S), is the standard gauge for copper, aluminum and other conductors, however the Steel Wire Gauge (SWG) is used for steel conductors.

NOTE

The Birmingham Wire Gauge is obsolete.

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